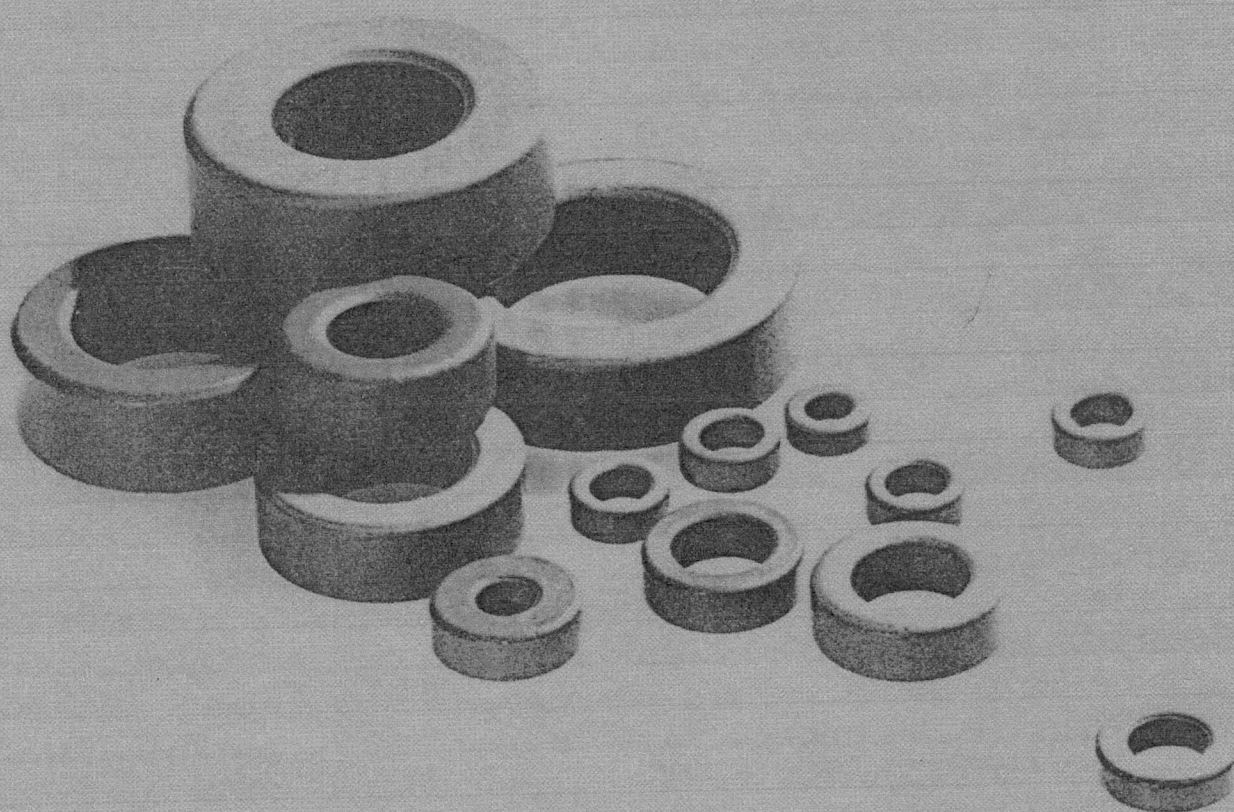


IRON-POWDER and FERRITE *COIL FORMS*



AMIDON
Associates, INC.

IRON-POWDER and KERRITE

COIL FORMS



RAMBOLD
LAWSON

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INTRODUCTION to the IRON POWDERS

In the past few decades, the use of solid state material for DC electro-magnetics, and later laminated magnetic materials for low frequency applications led to the need for materials that would operate efficiently at higher and higher frequencies. With the original thick laminations it was discovered that the apparent permeability, or inductance would decrease as frequency was increased, and at the same time core losses became prohibitive. It was found that by using thinner sheets of material, insulated from each other, better results could be obtained and that this was primarily due to an effect that was called eddy current shielding. It was also found that as frequency was increased, with any given material, the depth of magnetic penetration would decrease, and by using thinner sheets more of the core body could be utilized. This progression worked toward thinner laminations and grain oriented alloys to meet the higher frequency needs.

While the thin oriented laminations were useful for broadband audio transformers, they were unable to meet the need for selective circuits where high 'Q' was required. At low frequency the magnetic field in a coil is in its axial direction. At high frequency each turn generates its own field concentric with the wire. These fields are coupled with other fields from adjacent turns, and then both are coupled to the core axial fields, rather than by one central field. This type of field requires a core with laminations in all directions in order to minimize losses and maintain a reliable inductance and 'Q' in relation to frequency. As a result, Powdered Iron cores were developed.

There are two basic classes of iron powder material available. (1) The Carbonyl Irons, and (2) the Hydrogen Reduced Irons.

The CARBONYL IRONS have smaller particles which are formed by the decomposition of penta-carbonyl iron vapor. This produces a spherical particle with an 'onion skin' structure. The laminating affect of the 'onion skin' structure produces a resistivity of the individual particles which is much higher than that of pure iron.

continued

INTRODUCTION to the IRON POWDERS.

continued

This high resistance, in conjunction with the very small particle size greatly enhances the high frequency performance. The permeability of Carbonyl Iron cores, and thus their inductance, can be manufactured to a very tight tolerance, and they will remain extremely stable with frequency change, temperature change, and applied signal level. All of these are important considerations in high 'Q' selective circuits. The distributed air-gap of the carbonyl iron can produce cores with permeabilities ranging from 3 to 35 μ . This feature and the high saturation point of this material make carbonyl iron cores very useful for high frequency power circuits. Normally high power applications are limited by temperature rise rather than core saturation.

The HYDROGEN REDUCED IRONS have low resistance and a relative large particle size. This type of powder can produce cores of the higher permeabilities, from 35 to 90 μ . It has very low losses at low frequency, but the losses increase significantly as the frequency increases. Cores from this type of material are commonly used for differential-mode chokes in line filters and DC output chokes in switching power supplies.

Ferrite materials, developed in the 1930's, can produce cores with higher permeability than obtainable with Iron Powder. This may be of a distinct advantage in many cases where high inductance is required. However, in other circuits, especially hi-Q circuits, and where environmental and electrical conditions may constantly change, good stability may be more important than high permeability. Iron Powder cores can satisfy this requirement.

TOROIDAL CORES in general are the most efficient of any core configuration. They are highly self shielding since most of the lines of flux are contained within the toroidal form. The flux lines are essentially uniform over the entire magnetic path length and consequently stray magnetic fields will have very little effect on a toroidal inductor. It is seldom necessary to shield a toroidal core to prevent feedback or cross-talk.

Iron Powder Materials

MATERIAL #0 (permeability 1) Material 0 has a permeability of one and is most commonly used for frequencies above 200 Mhz.

MATERIAL #1 (permeability 20) A Carbonyl 'C' material offering high volume resistivity and good stability covering a frequency range from .5 MHz. to 5. MHz.

MATERIAL #2 (permeability 10) A Carbonyl 'E' iron powder material which has high volume resistivity and offers high 'Q' for the 1 to 30 MHz. frequency range.

MATERIAL #3 (permeability 35) A carbonyl 'HP' material having good stability and good 'Q' for the 50 KHz to 500 KHz frequency range.

MATERIAL #6 (permeability 8) A carbonyl 'SF' material very similar to #2 material but has an improved 'Q' for frequencies 3 MHz to 50 MHz.

MATERIAL #10 (permeability 6) A powdered iron carbonyl 'W' material offering good 'Q' and high stability for frequencies 5 MHz to 100 MHz.

MATERIAL #15 (permeability 25) A carbonyl 'GS6' material having good stability and good 'Q'. A good choice for commercial broadcast band where good 'Q' and stability are essential.

MATERIAL #17 (permeability 3) An upgrade of previous #12 having better temperature stability. A synthetic Oxide material which can provide good 'Q' for frequencies 20 to 200 MHz..

MATERIAL #26 (permeability 75) A Hydrogen Reduced material. Has the highest permeability of all of the iron powder materials. Used for EMI filters and DC chokes. #26 is very similar to the older #41 material but provides and extended frequency range.

A_L VALUES for Iron Powder cores are generally given in microhenries per 100 turns. A_L value for each individual core will be found on the following pages. Use formula below for turns vs. inductance.

Turns Formula	Key to part number						
$\text{Turns} = 100 \sqrt{\frac{\text{desired } L \text{ (uh)}}{A_L \text{ (uh/100t)}}$	<table border="0" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">T</td> <td style="text-align: center;">- 50</td> <td style="text-align: center;">- 6</td> </tr> <tr> <td style="text-align: center;">toroid</td> <td style="text-align: center;">outer-diameter</td> <td style="text-align: center;">material</td> </tr> </table>	T	- 50	- 6	toroid	outer-diameter	material
T	- 50	- 6					
toroid	outer-diameter	material					

SUBSTANTIAL QUANTITIES of most catalog items are maintained in stock for immediate delivery.

IRON POWDER TOROIDAL CORES For Resonant Circuits

MATERIAL 0 Perm. 1 Freq. Range 30 - 300 MHz Color code - tan

Core number \\	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-0	.125	.062	.050	0.74	.010	.007	3.0
T-16-0	.160	.078	.060	0.95	.016	.015	3.0
T-20-0	.200	.088	.070	1.15	.025	.029	3.5
T-25-0	.255	.120	.096	1.50	.042	.063	4.5
T-30-0	.307	.151	.128	1.83	.065	.119	6.0
T-37-0	.375	.205	.128	2.32	.070	.162	4.9
T-44-0	.440	.229	.159	2.67	.107	.286	6.5
T-50-0	.500	.303	.190	3.03	.121	.367	6.4
T-68-0	.690	.370	.190	4.24	.196	.831	7.5
T-80-0	.795	.495	.250	5.15	.242	1.246	8.5
T-94-0	.942	.560	.312	6.00	.385	2.310	10.6
T-106-0	1.060	.570	.437	6.50	.690	4.485	19.0
T-130-0	1.300	.780	.437	8.29	.730	6.052	15.0

MATERIAL 1 Perm 20 Freq. Range .5 - 1 MHz Color code - Blue

Core number \\	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-1	.125	.062	.050	0.74	.010	.007	43
T-16-1	.160	.078	.060	0.95	.016	.015	44
T-20-1	.200	.088	.070	1.15	.025	.029	52
T-25-1	.255	.120	.096	1.50	.042	.063	70
T-30-1	.307	.151	.128	1.83	.065	.119	85
T-37-1	.375	.205	.128	2.32	.070	.162	80
T-44-1	.440	.229	.159	2.67	.107	.286	105
T-50-1	.500	.303	.190	3.03	.121	.367	100
T-68-1	.690	.370	.190	4.24	.196	.831	115
T-80-1	.795	.495	.250	5.15	.242	1.246	115
T-94-1	.942	.560	.312	6.00	.385	2.310	160
T-106-1	1.060	.570	.437	6.50	.690	4.485	325
T-130-1	1.300	.780	.437	8.29	.730	6.052	200
T-157-1	1.570	.950	.570	10.05	1.140	11.457	320
T-184-1	1.840	.950	.710	11.12	2.040	22.685	500
T-200-1	2.000	1.250	.550	12.97	1.330	17.250	250

Note: All frequency ranges given throughout this booklet are based on the area of highest 'Q'. The useful frequency range of all cores will extend greatly beyond the given figures in both directions, but a lower 'Q' should be expected.

MATERIAL 2 Perm. 10 Freq. Range 1 - 30 MHz Color code - Red

Core number V/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-2	.125	.062	.050	0.74	.010	.007	20
T-16-2	.160	.078	.060	0.95	.016	.015	22
T-20-2	.200	.088	.070	1.15	.025	.029	27
T-25-2	.255	.120	.096	1.50	.042	.063	34
T-30-2	.307	.151	.128	1.83	.065	.119	43
T-37-2	.375	.205	.128	2.32	.070	.162	40
T-44-2	.440	.229	.159	2.67	.107	.286	52
→ T-50-2	.500	.303	.190	3.03	.121	.367	49
→ T-68-2	.690	.370	.190	4.24	.196	.831	57
T-80-2	.795	.495	.250	5.15	.242	1.246	55
T-94-2	.942	.560	.312	6.00	.385	2.310	84
T-106-2	1.060	.570	.437	6.50	.690	4.485	135
T-130-2	1.300	.780	.437	8.29	.730	6.052	110
T-157-2	1.570	.950	.570	10.05	1.140	11.457	140
T-184-2	1.840	.950	.710	11.12	2.040	22.685	240
T-200-2	2.000	1.250	.550	12.97	1.330	17.250	120
T-200A-2	2.000	1.250	1.000	12.97	2.240	29.050	218
T-225 -2	2.250	1.405	.550	14.56	1.508	21.956	120
T-225A-2	2.250	1.485	1.000	14.56	2.730	39.749	215
T-300 -2	3.058	1.925	.500	19.83	1.810	35.892	114
T-300A-2	3.048	1.925	1.000	19.83	3.580	70.991	228
T-400 -2	4.000	2.250	.650	24.93	3.660	91.244	180
T-400A-2	4.000	2.250	1.300	24.93	7.432	185.280	360
T-520 -2	5.200	3.080	.800	33.16	5.460	181.000	207

MATERIAL 3 Perm 35 Freq. Range .05 -.5 MHz Color code - Gray

Core number V/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-3	.125	.062	.050	0.74	.010	.007	60
T-16-3	.160	.078	.060	0.95	.016	.015	61
T-20-3	.200	.088	.070	1.15	.025	.029	90
T-25-3	.255	.120	.096	1.50	.042	.063	100
T-30-3	.307	.151	.128	1.83	.065	.119	140
T-37-3	.375	.205	.128	2.32	.070	.162	120
T-44-3	.440	.229	.159	2.67	.107	.286	180
T-50-3	.500	.303	.190	3.03	.121	.367	175
T-68-3	.690	.370	.190	4.24	.196	.831	195
T-80-3	.795	.495	.250	5.15	.242	1.246	180
T-94-3	.942	.560	.312	6.00	.385	2.310	248
T-106-3	1.060	.570	.437	6.50	.690	4.485	450
T-130-3	1.300	.780	.437	8.29	.730	6.052	350
T-157-3	1.570	.950	.570	10.05	1.140	11.457	420
T-184-3	1.840	.950	.710	11.12	2.040	22.685	720
T-200-3	2.000	1.250	.550	12.97	1.330	17.250	425
T-200A-3	2.000	1.250	1.000	12.97	2.240	29.050	460
T-225 -3	2.250	1.405	.550	14.56	1.508	21.956	425

IRON POWDER TOROIDAL CORES For Resonant Circuits

MATERIAL 6 Perm. 8 Freq. Range 3 - 50 MHz. Color code - Yellow

Core number	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-6	.125	.062	.050	0.74	.010	.007	17
T-16-6	.160	.078	.060	0.95	.016	.015	19
T-20-6	.200	.088	.070	1.15	.025	.029	22
T-25-6	.255	.120	.096	1.50	.042	.063	27
T-30-6	.307	.151	.128	1.83	.065	.119	36
T-37-6	.375	.205	.128	2.32	.070	.162	30
T-44-6	.440	.229	.159	2.67	.107	.286	42
T-50-6	.500	.303	.190	3.03	.121	.367	40
T-68-6	.690	.370	.190	4.24	.196	.831	47
T-80-6	.795	.495	.250	5.15	.242	1.246	45
T-94-6	.942	.560	.312	6.00	.385	2.310	70
T-106-6	1.060	.570	.437	6.50	.690	4.485	116
T-130-6	1.300	.780	.437	8.29	.730	6.052	96
T-157-6	1.570	.950	.570	10.05	1.140	11.457	115
T-184-6	1.840	.950	.710	11.12	2.040	22.685	195
T-200-6	2.000	1.250	.550	12.97	1.330	17.250	100
T-200A-6	2.000	1.250	1.000	12.97	2.240	29.050	180
T-225-6	2.250	1.405	.550	14.56	1.508	21.956	100

MATERIAL 10 Perm 6 Freq. Range 5 - 100 MHz. Color - black

Core number	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-12-10	.125	.062	.050	0.74	.010	.007	12
T-16-10	.160	.078	.060	0.95	.016	.015	13
T-20-10	.200	.088	.070	1.15	.025	.029	16
T-25-10	.255	.120	.096	1.50	.042	.063	19
T-30-10	.307	.151	.128	1.83	.065	.119	25
T-37-10	.375	.205	.128	2.32	.070	.162	25
T-44-10	.440	.229	.159	2.67	.107	.286	33
T-50-10	.500	.303	.190	3.03	.121	.367	31
T-68-10	.690	.370	.190	4.24	.196	.831	22
T-80-10	.795	.495	.250	5.15	.242	1.246	33
T-94-10	.942	.560	.312	6.00	.385	2.310	58

IRON POWDER TOROIDAL CORES For Resonant Circuits

MATERIAL 15 Perm 25 Freq. Range .1 - 2. MHz. Color code - Rd & Wh

Core number V/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I _e (cm)	A _e ² (cm) ²	V _e ³ (cm) ³	A _L Value uh/100 turns
T-12-15	.125	.062	.050	0.74	.010	.007	50
T-16-15	.160	.078	.060	0.95	.016	.015	55
T-20-15	.200	.088	.070	1.15	.025	.029	65
T-25-15	.255	.120	.096	1.50	.042	.063	85
T-30-15	.307	.151	.128	1.83	.065	.119	93
T-37-15	.375	.205	.128	2.32	.070	.162	90
T-44-15	.440	.229	.159	2.67	.107	.286	160
T-50-15	.500	.303	.190	3.03	.121	.367	135
T-68-15	.690	.370	.190	4.24	.196	.831	180
T-80-15	.795	.495	.250	5.15	.242	1.246	170
T-94-15	.942	.560	.312	6.00	.385	2.310	200
T-106-15	1.060	.570	.437	6.50	.690	4.485	345
T-130-15	1.300	.780	.437	8.29	.730	6.052	250
T-157-15	1.570	.950	.570	10.05	1.140	11.457	360

MATERIAL 12/17 Perm. 3 Freq. Range 20 - 200 MHz Color code - Blu & Yel.

Core number V/	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I _e (cm)	A _e ² (cm) ²	V _e ³ (cm) ³	A _L Value uh/100 turns
T-12-12	.125	.062	.050	0.74	.010	.007	7.5
T-16-12	.160	.078	.060	0.95	.016	.015	8.0
T-20-12	.200	.088	.070	1.15	.025	.029	10.0
T-25-12	.255	.120	.096	1.50	.042	.063	12.0
T-30-12	.307	.151	.128	1.83	.065	.119	16.0
T-37-12	.375	.205	.128	2.32	.070	.162	15.0
T-44-12	.440	.229	.159	2.67	.107	.286	18.5
T-50-12	.500	.303	.190	3.03	.121	.367	18.0
T-68-12	.690	.370	.190	4.24	.196	.831	21.0
T-80-12	.795	.495	.250	5.15	.242	1.246	22.0
T-94-12	.942	.560	.312	6.00	.385	2.310	22.0

MATERIAL 26

See page 32, 'AC Line Filter and DC Choke' section.

The following equations are useful for calculating the number of turns, the inductance or the A_L value of any Iron Powder toroidal core. Each core has been assigned its own A_L value which is found in the preceding Iron Powder toroidal core charts.

$$N = 100 \sqrt{\frac{\text{desired 'L' (uh)}}{A_L \text{ (uh/100 turns) }}}$$

$$L \text{ (uh)} = \frac{A_L \times N^2}{10,000}$$

$$A_L \text{ (uh /100 turns)} = \frac{10,000 \times 'L' \text{ (uh)}}{N^2}$$

N = number of turns:

L = inductance (uh)

A_L = inductance index (uh / 100 turns)

IRON POWDER TOROIDAL CORES

Physical Dimensions

Core Size	Outer diam. (in)	Inner diam. (in)	Height (in)	Mean lgth. (cm)	Cross sect. (cm ²)	Core Size	Outer diam. (in)	Inner diam. (in)	Height (in)	Mean lgth. (cm)	Cross sect. (cm ²)
T-12	.125	.062	.050	0.75	.010	T-130	1.30	.78	.437	8.29	0.73
T-16	.160	.078	.060	0.95	.016	T-157	1.57	.95	.570	10.05	1.14
T-20	.200	.088	.070	1.15	.025	T-184	1.84	.95	.710	11.12	2.04
T-25	.250	.120	.096	1.50	.042	T-200	2.00	1.25	.550	12.97	1.33
T-30	.307	.151	.128	1.83	.065	T-200A	2.00	1.25	1.000	12.97	2.42
T-37	.375	.205	.128	2.32	.070	T-225	2.25	1.40	.550	14.56	1.50
T-44	.440	.229	.159	2.67	.107	T-225A	2.25	1.40	1.000	14.56	2.73
T-50	.500	.300	.190	3.20	.121	T-300	3.00	1.92	.500	19.83	1.81
T-68	.690	.370	.190	4.24	.196	T-300A	3.00	1.92	1.000	19.83	3.58
T-80	.795	.495	.250	5.15	.242	T-400	4.00	2.25	.650	24.93	3.66
T-94	.942	.560	.312	6.00	.385	T-400A	4.00	2.25	1.000	24.93	7.43
T-106	1.060	.570	.437	6.50	.690	T-500	5.20	3.08	.800	33.16	5.46

AL Values (uh / 100 turns)

For complete part number, add Mix number to Core Size number.

Core Size	26 Mix Yel-Wh u = 75 Mhz > to 1.0	3 Mix Gray u = 35 .05 - 5.	15 Mix Rd-Wh u = 25 .1 - 2.	1 Mix Blue u = 20 .5 - 5.	2 Mix Red u = 10 1 - 30	6 Mix Yellow u = 8 3 - 50	10 Mix Black u = 6 5 - 100	12/17 Mix Grn-Wh u = 3.5 20-200	0 Mix Tan u = 1 50-300
T-12-	na	60	50	48	20	17	12	7.0	3.0
T-16-	na	61	55	44	22	19	13	8.0	3.0
T-20-	na	90	65	52	27	22	16	10.0	3.5
T-25-	na	100	100	70	34	27	19	12.0	4.5
T-30-	325	140	93	85	43	36	25	16.0	6.0
T-37-	275	120	90	80	40	30	25	15.0	4.9
T-44-	360	180	160	105	52	42	33	19.0	6.5
T-50-	320	175	135	100	49	40	31	18.0	6.4
T-68-	420	195	180	115	57	47	32	21.0	7.5
T-80-	450	180	170	115	55	45	32	22.0	8.5
T-94-	590	248	200	160	84	70	58	32.0	10.6
T-106-	900	450	345	325	135	116	na	na	19.0
T-130-	785	350	250	200	110	96	na	na	15.0
T-157-	970	420	360	320	140	115	na	na	na
T-184-	1640	720	na	500	240	na	na	na	na
T-200-	895	425	na	250	120	100	na	na	na
T-200A-	1550	na	na	na	218	180	na	na	na
T-225-	950	424	na	na	120	100	na	na	na
T-225A-	1600	na	na	na	215	na	na	na	na
T-300-	825	na	na	na	115	na	na	na	na
T-300A-	1600	na	na	na	228	na	na	na	na
T-400-	1320	na	na	na	185	na	na	na	na
T-400A-	2600	na	na	na	360	na	na	na	na
T-500-	1460	na	na	na	207	na	na	na	na

na - not available.

Note: #12 material will eventually be superseded by the #17 material.

Wire size AWG	Diameter in inches (enamel)	Circular mil area	Turns per linear inch	Turns per sq.cm	Continuous duty current (amps) single wire, open air	Continuous duty, (amps) conduit or in wire bundles
8	.1285	16510	7.6		73	46
10	.1019	10380	10.7	13.8	55	33
12	.0808	6530	12.0	21.7	41	23
14	.0640	4107	15.0	34.1	32	17
16	.0508	2583	18.9	61.2	22	13
18	.0403	1624	23.6	79.1	16	10
20	.0319	1022	29.4	124.0	11	7.5
22	.0253	642	37.0	186.0	7	5.0
24	.0201	404	46.3	294.0	5	4
26	.0159	254	58.0	465.0	3	3
28	.0126	160	72.7	728.0	2	2
30	.0100	101	90.5	1085.0	1	1
32	.0079	63	113.0	1628.0	1	1
34	.0063	40	141.0	2480.0	1	1
36	.0050	25	175.0	3876.0	1	1
38	.0039	16	224.0	5736.0	1	1
40	.0031	10	382.0	10077.0	1	1

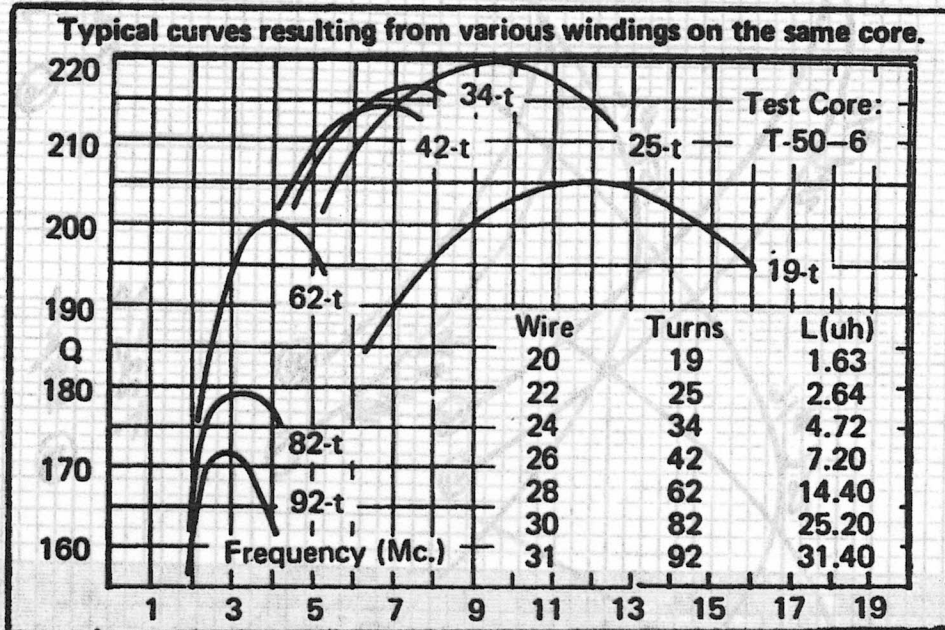
Iron Powder Core Size vs. Turns & Wire Size

Approximate number of turns for a full single layer winding

Wire Sz.	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Core\No.																
T-12	0	0	0	1	1	1	2	4	5	8	11	15	21	29	37	47
T-16	0	0	1	1	1	3	3	5	8	11	16	21	29	38	49	63
T-20	0	1	1	1	3	4	5	6	9	14	18	25	33	43	56	72
T-25	1	1	1	3	4	5	7	11	15	21	28	37	48	62	79	101
T-30	1	1	3	4	5	7	11	15	21	28	37	48	62	78	101	129
T-37	1	3	5	7	9	12	17	23	31	41	53	67	87	110	140	177
T-44	3	5	6	7	10	15	20	27	35	46	60	76	97	124	157	199
T-50	5	6	8	11	16	21	28	37	49	63	81	103	131	166	210	265
T-68	7	9	12	15	21	28	36	47	61	79	101	127	162	205	257	325
T-80	8	12	17	23	30	39	51	66	84	108	137	172	219	276	347	438
T-94	10	14	20	27	35	45	58	75	96	123	156	195	248	313	393	496
T-106	10	14	20	27	35	45	58	75	96	123	156	195	248	313	393	496
T-130	17	23	30	40	51	66	83	107	137	173	220	275	348	439	550	693
T-157	22	29	38	50	64	82	104	132	168	213	270	336	426	536	672	846
T-184	22	29	38	50	64	82	104	132	168	213	270	336	426	536	672	846
T-200	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
T-225	36	46	60	77	98	123	156	198	250	317	400	499	631	793	993	125
T-300	52	66	85	108	137	172	217	274	347	438	553	688	870	1093	1368	1721
T-400	61	79	100	127	161	202	255	322	407	513	648	806	1018	1278	1543	2012
T-520	86	110	149	160	223	279	349	443	559	706	889	1105	1396	1753	2192	275

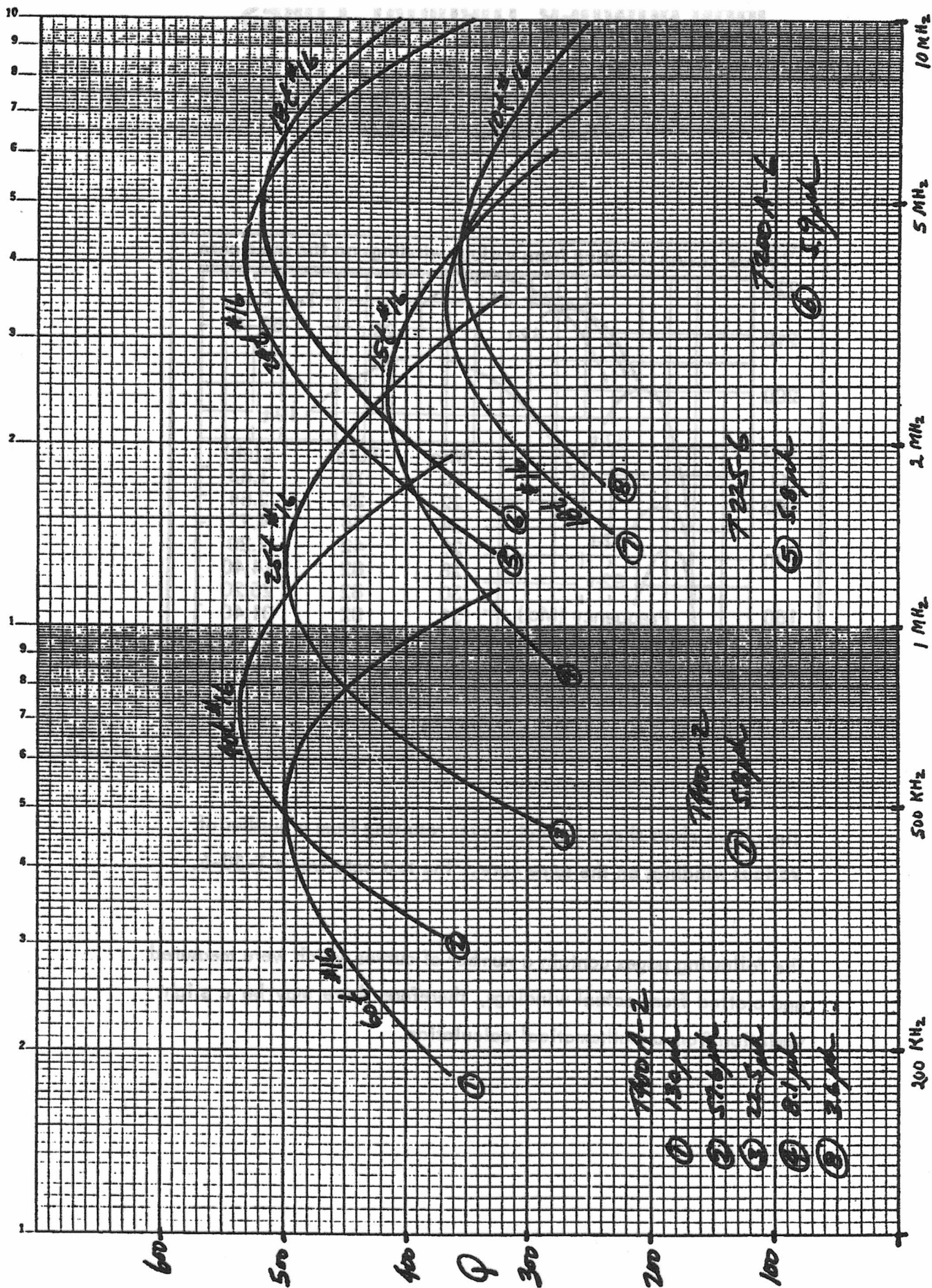
IRON-POWDER TOROIDAL CORES

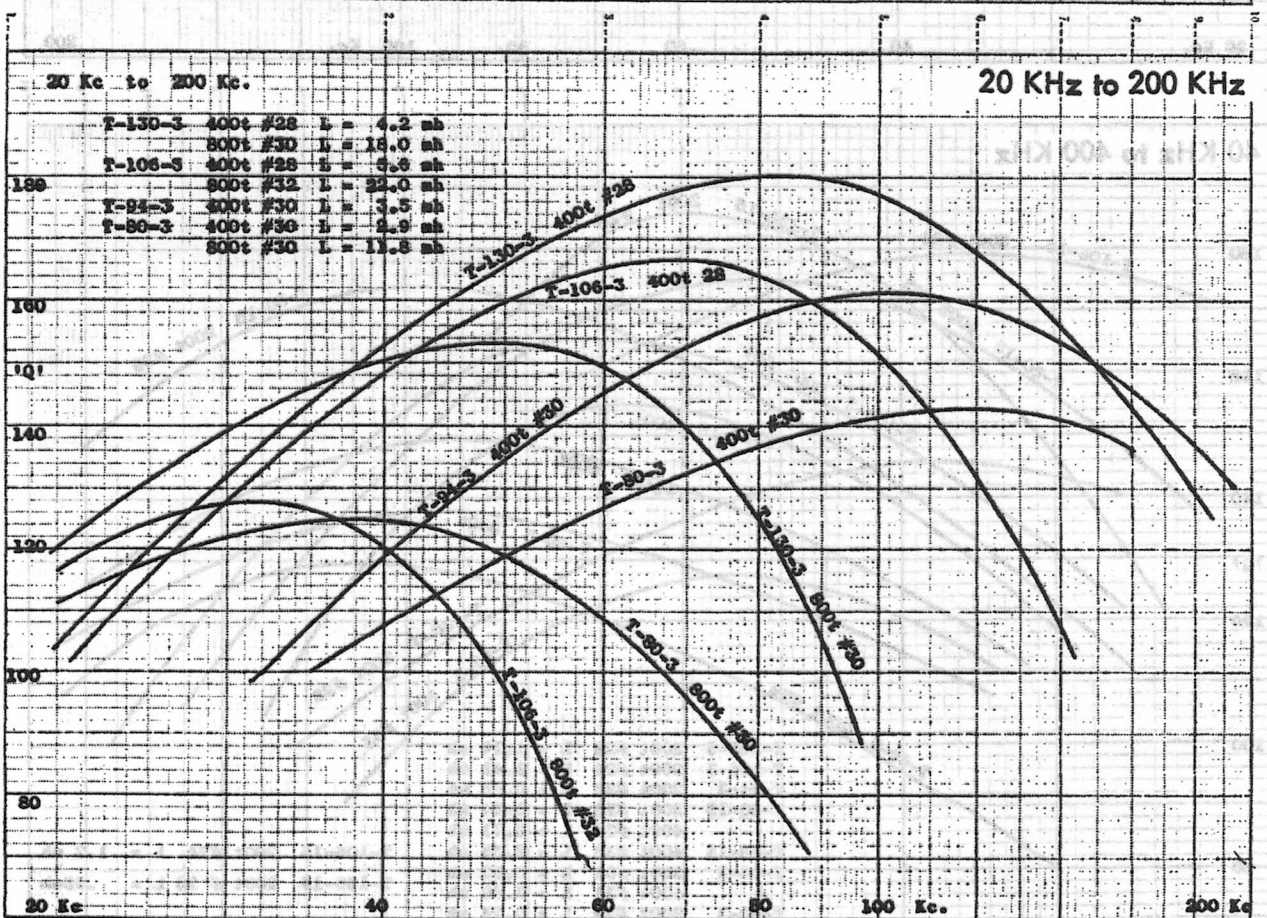
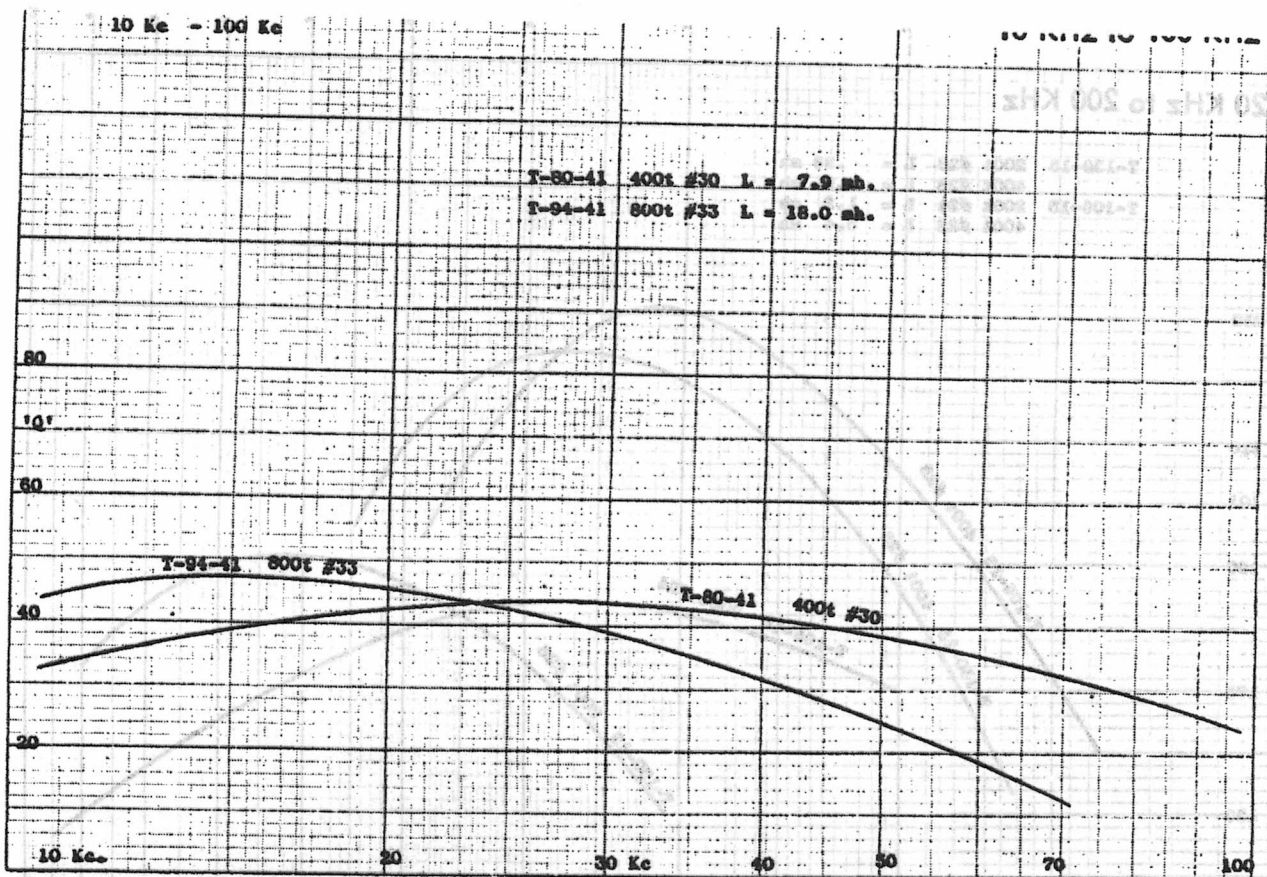
TYPICAL 'Q' CURVES various windings, same core

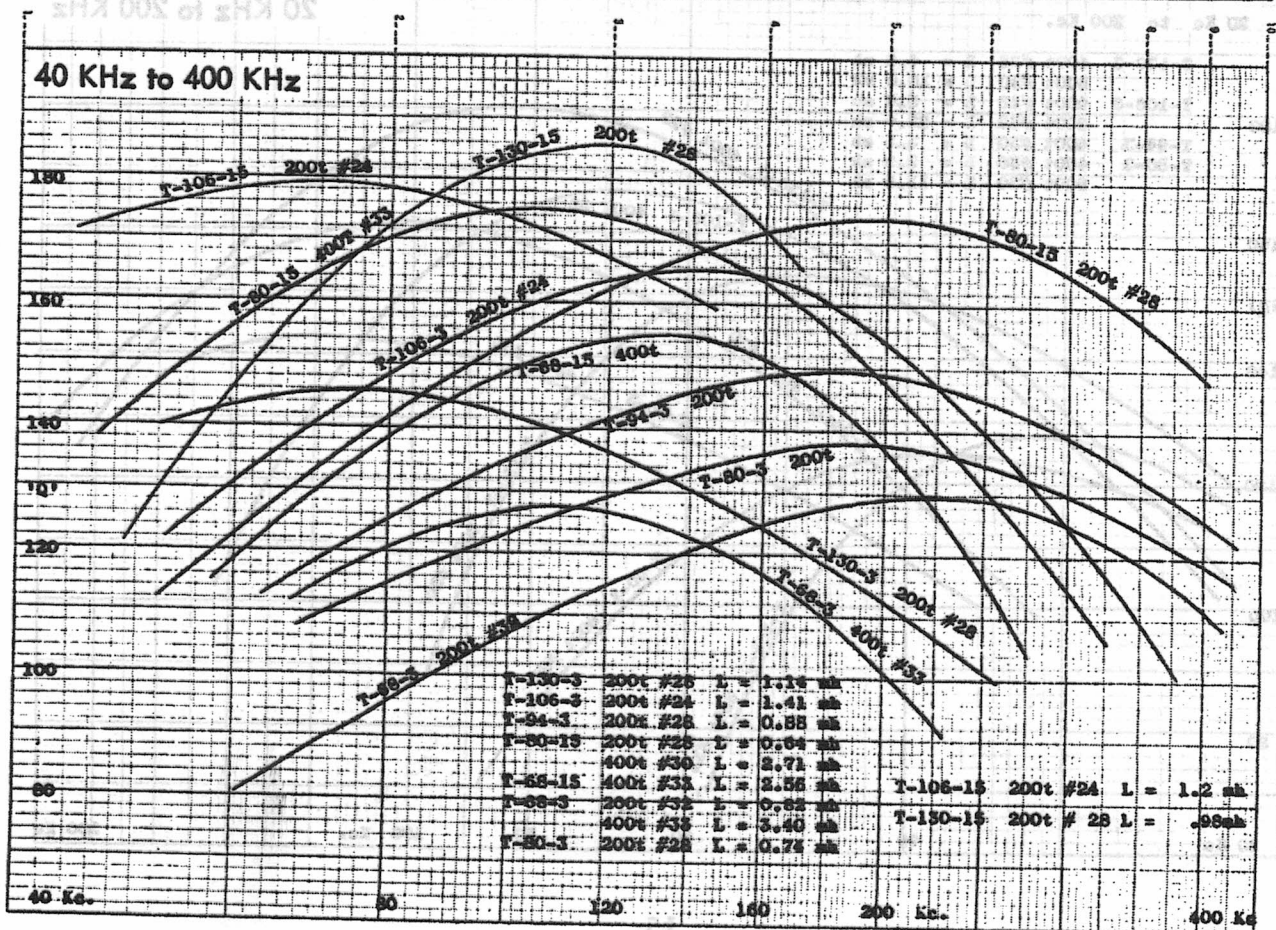
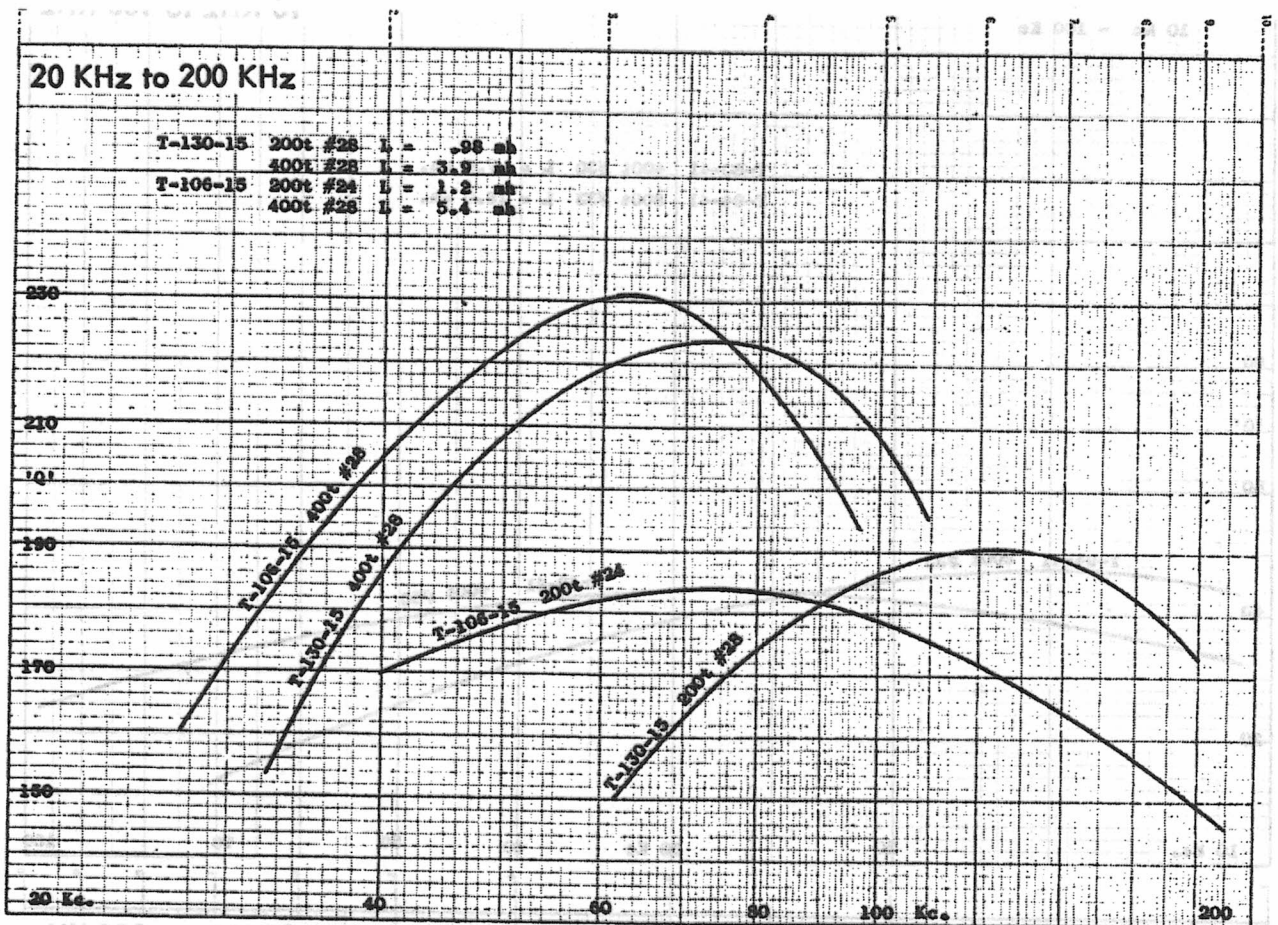


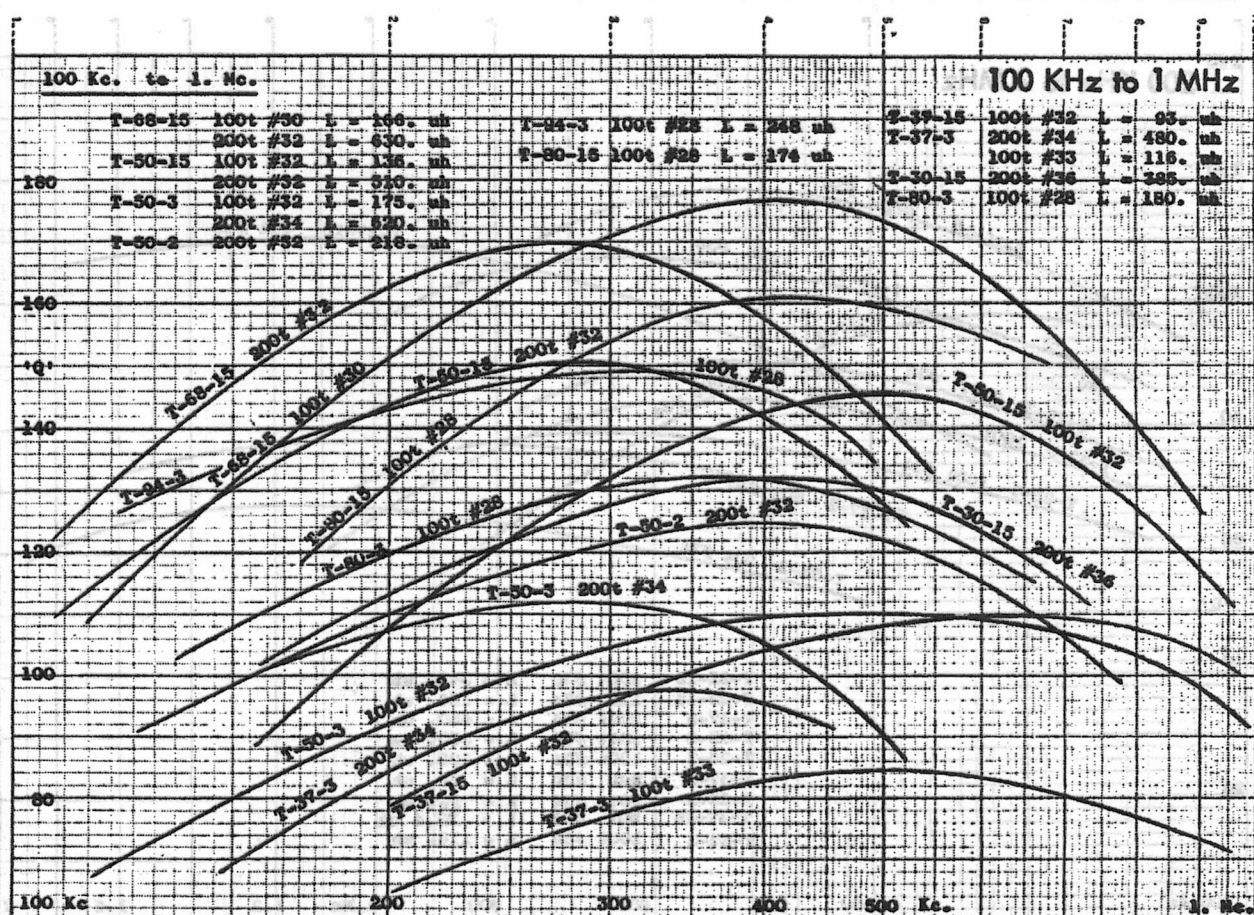
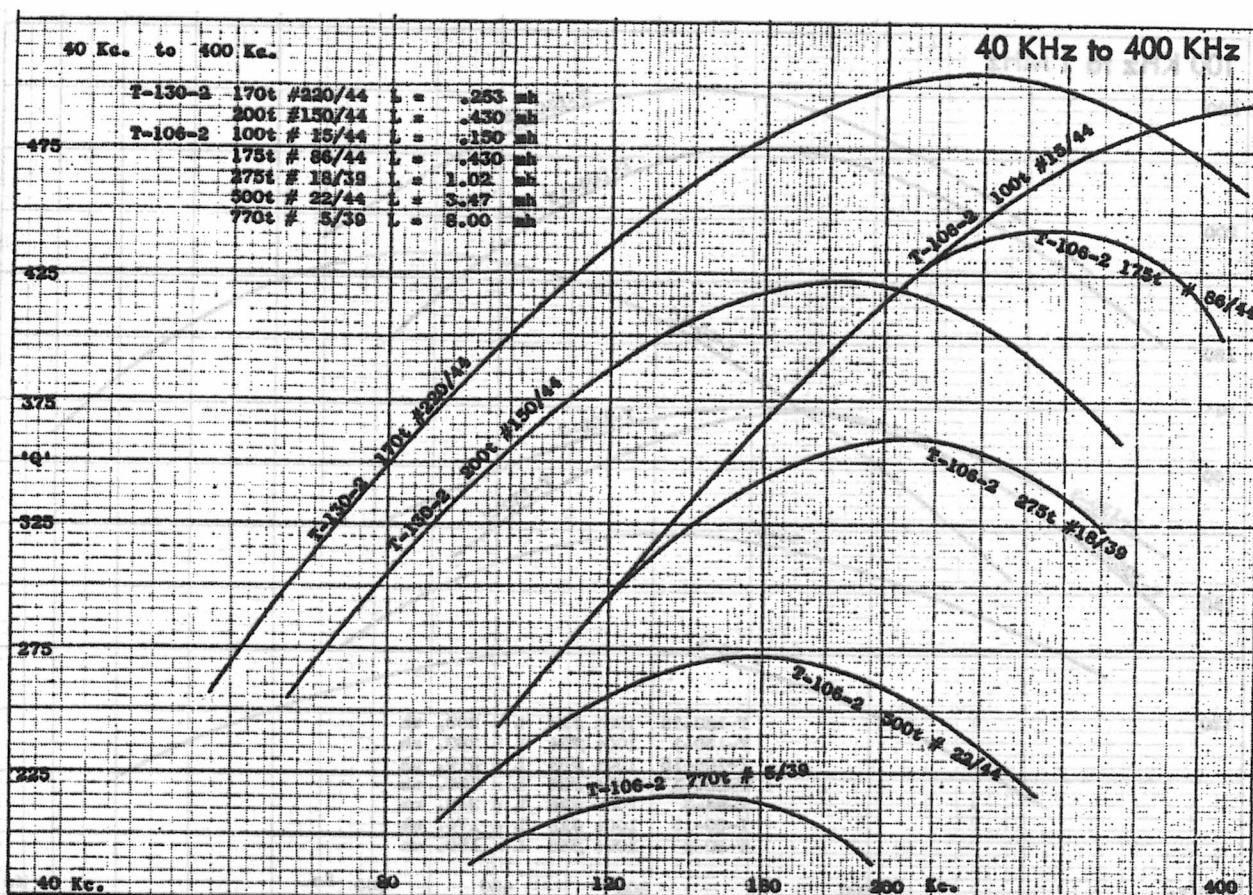
The above chart shows typical curves resulting from a number of various windings on the same core. The test core was a T-50-6.

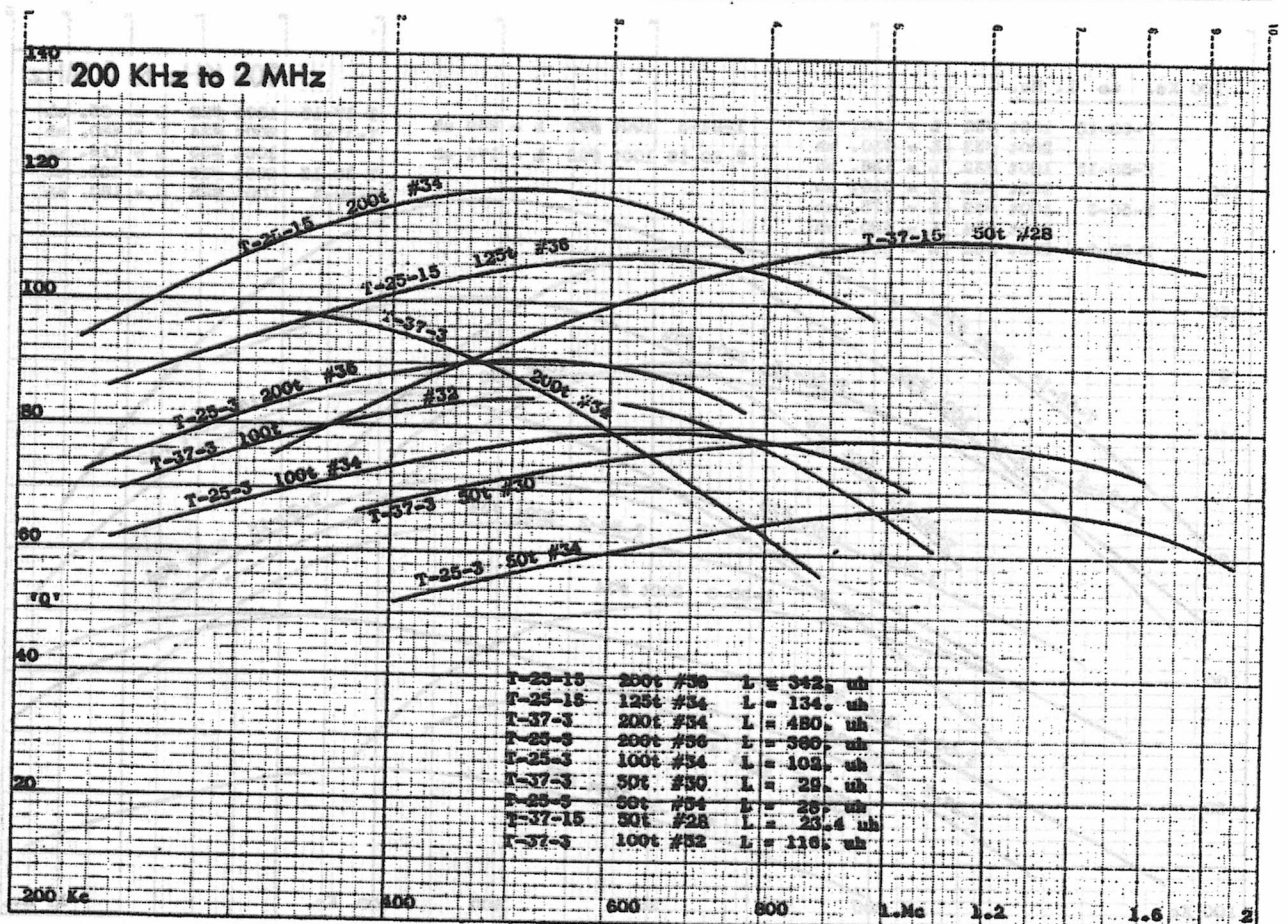
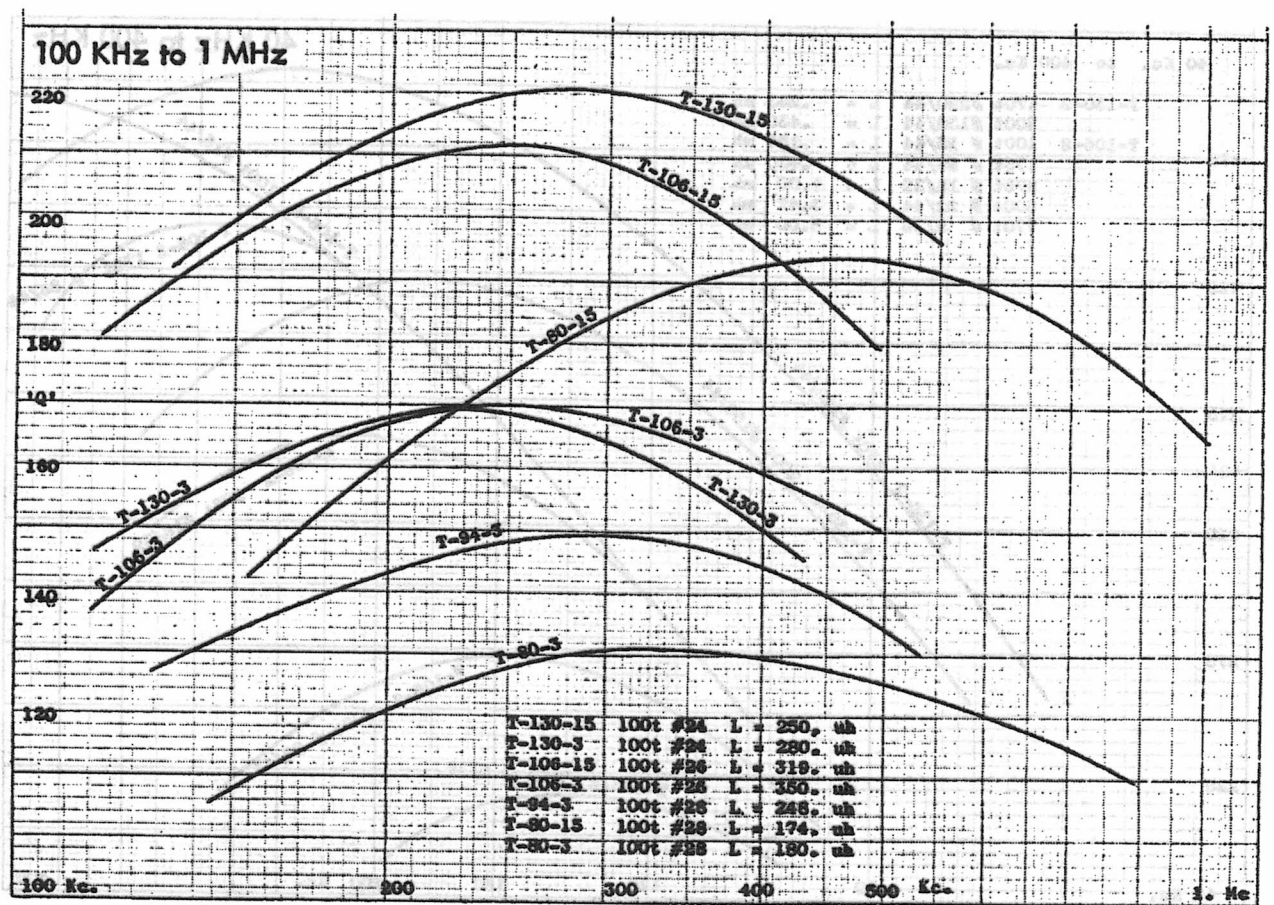
The following pages contain a number of curves which were measured and plotted from actual windings, therefore there may be a slight variation from a mathematical calculation.

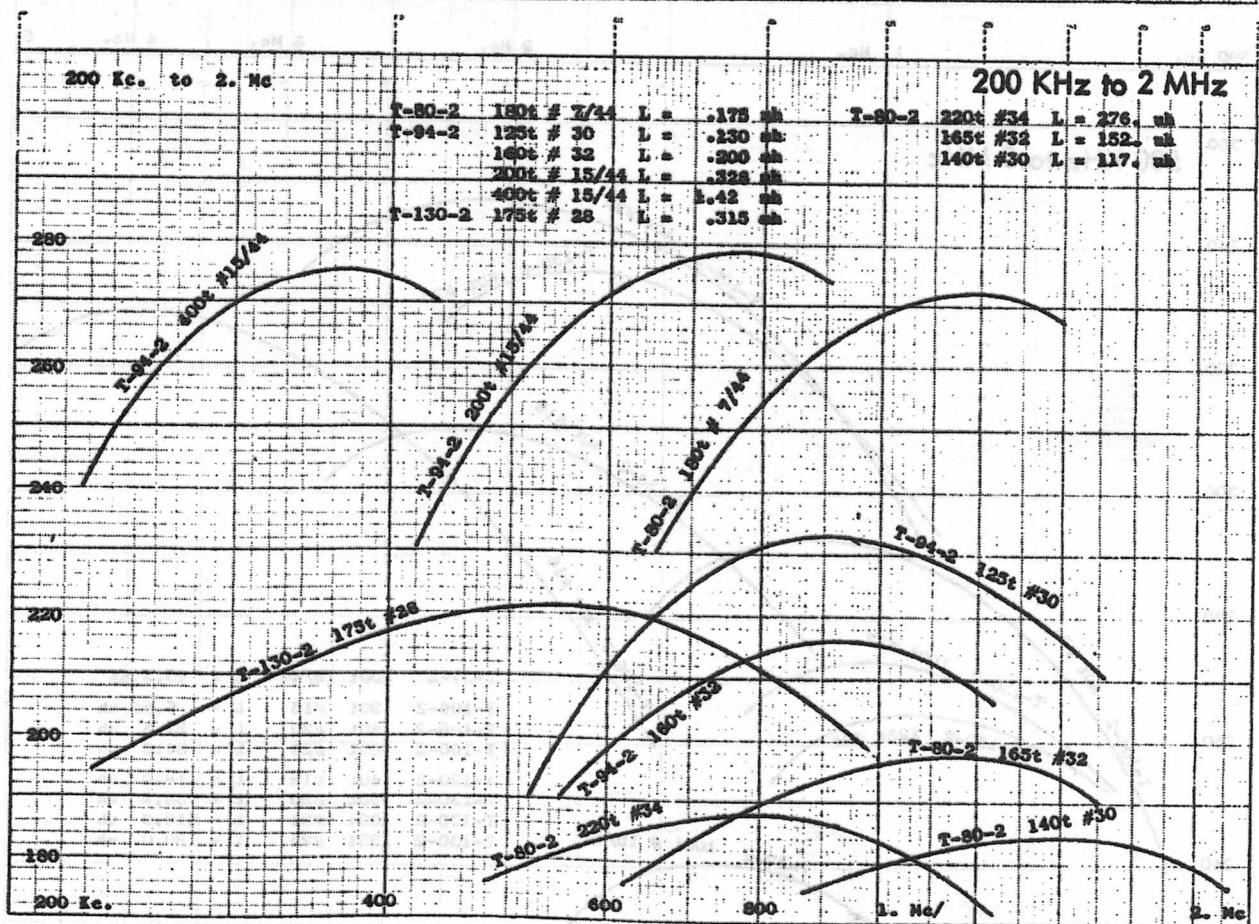
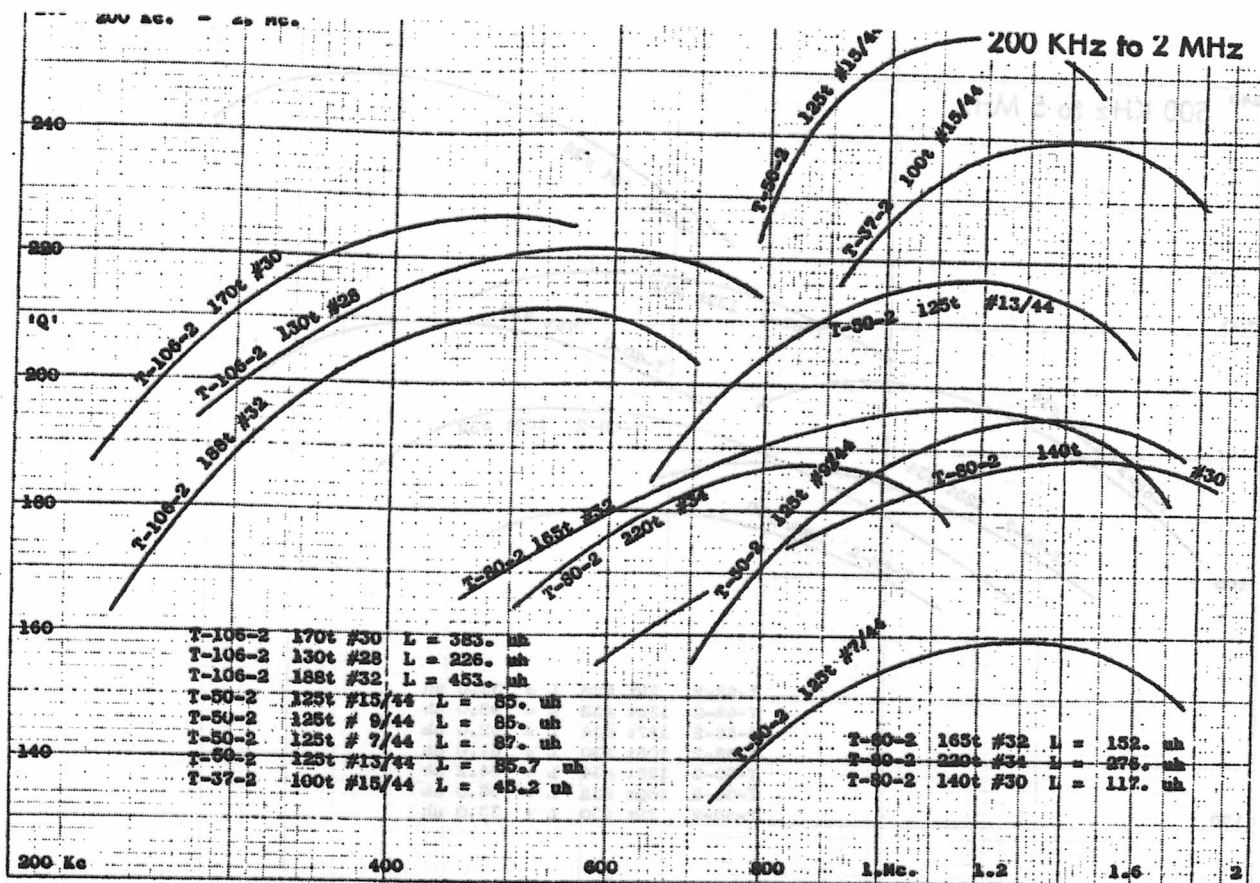


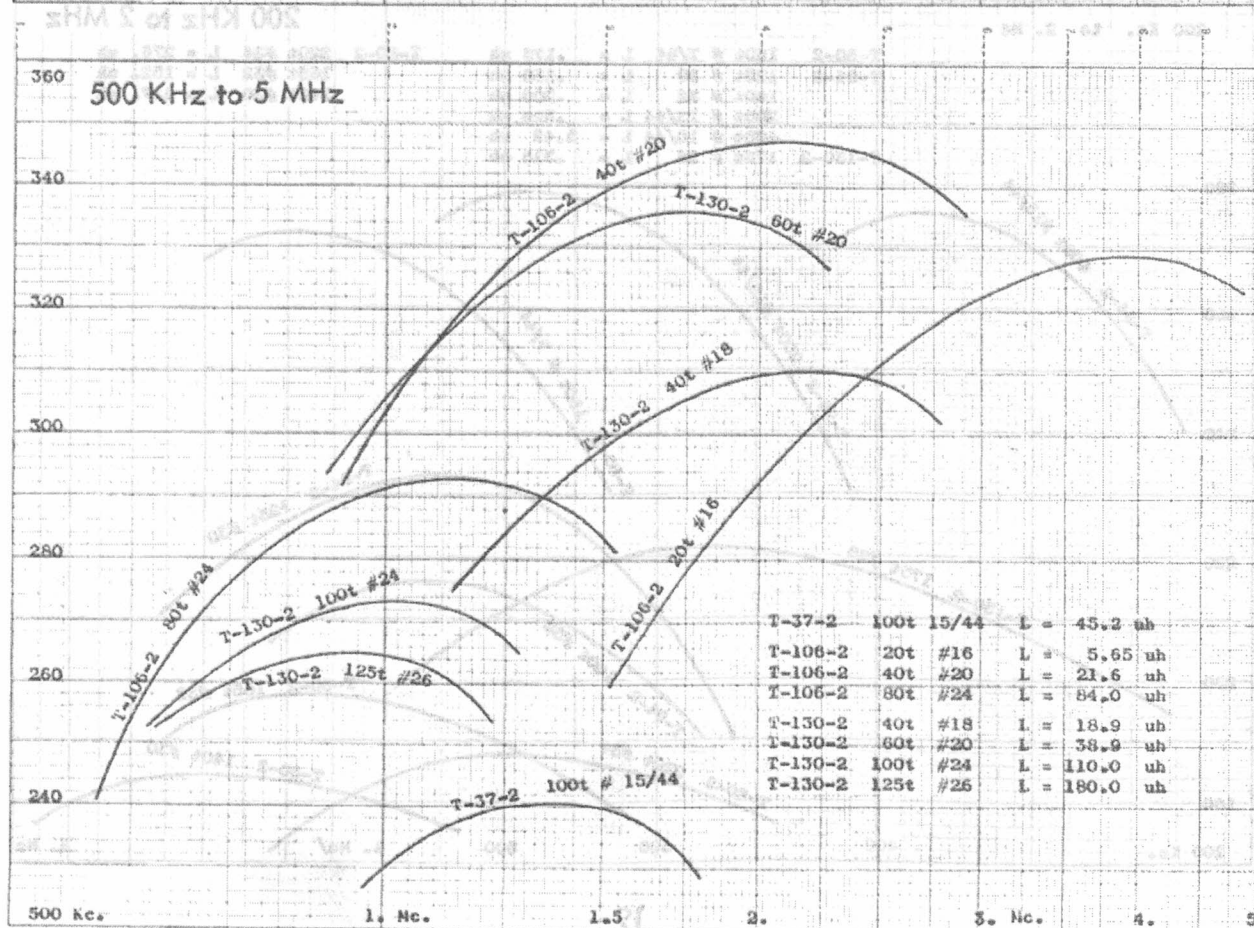
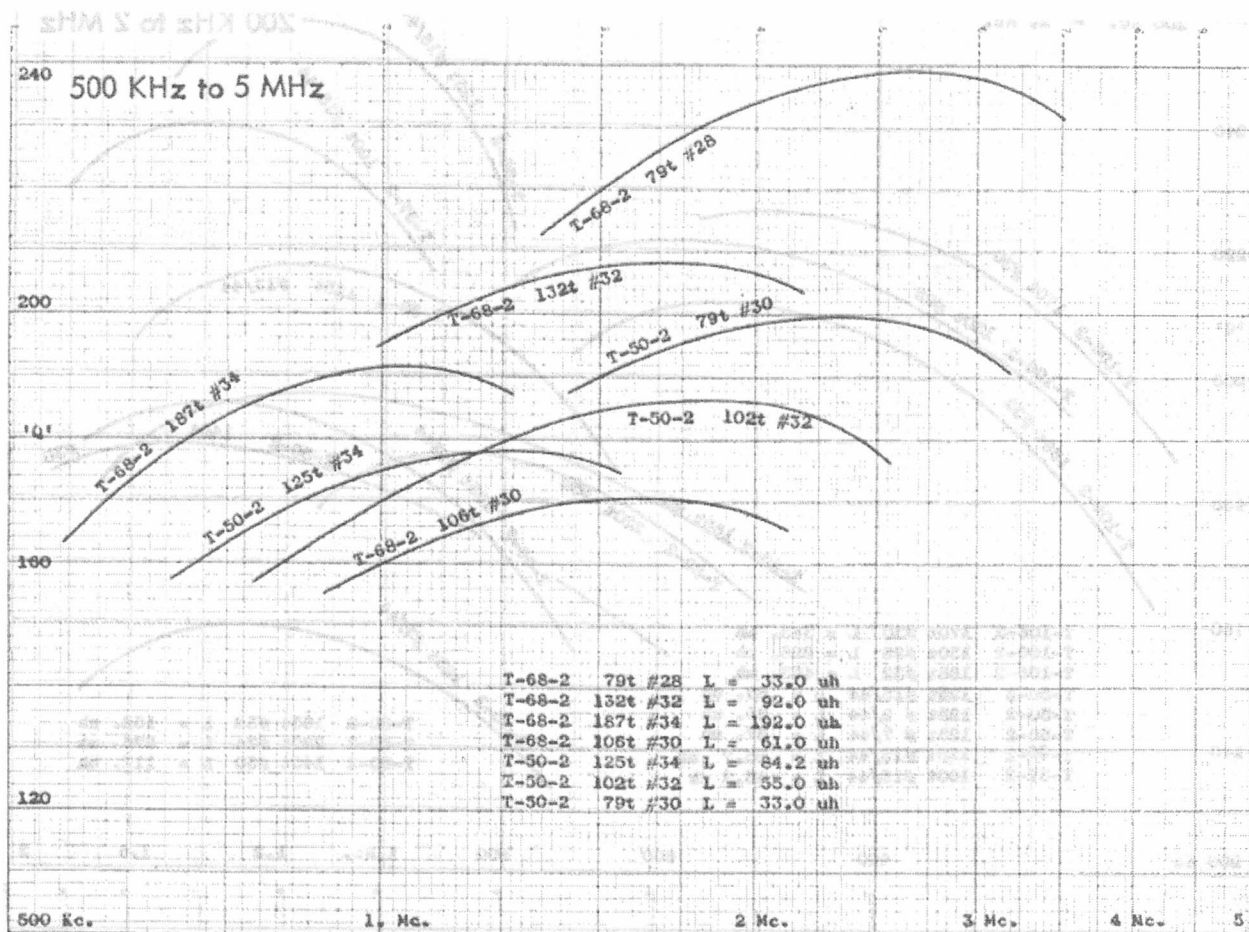






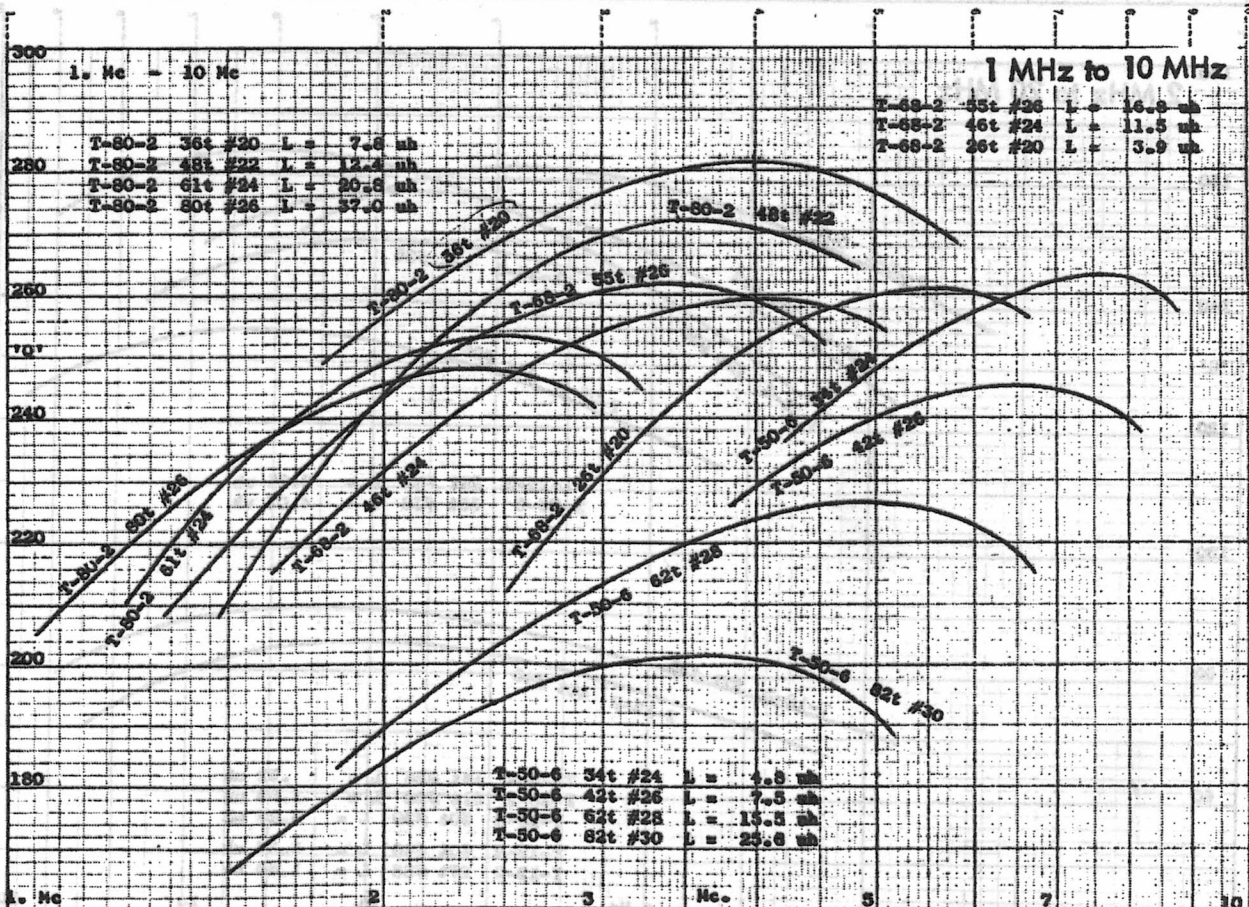
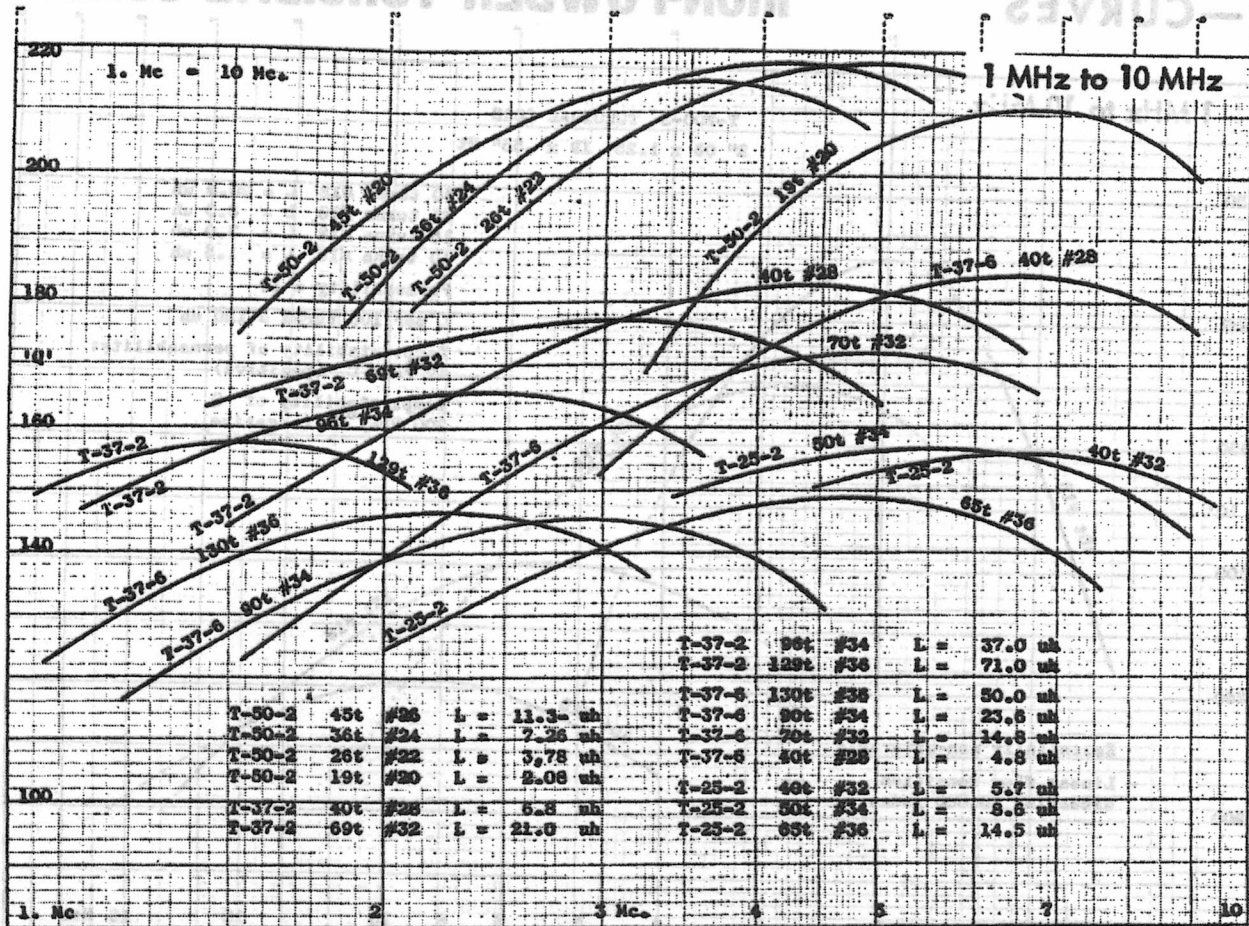






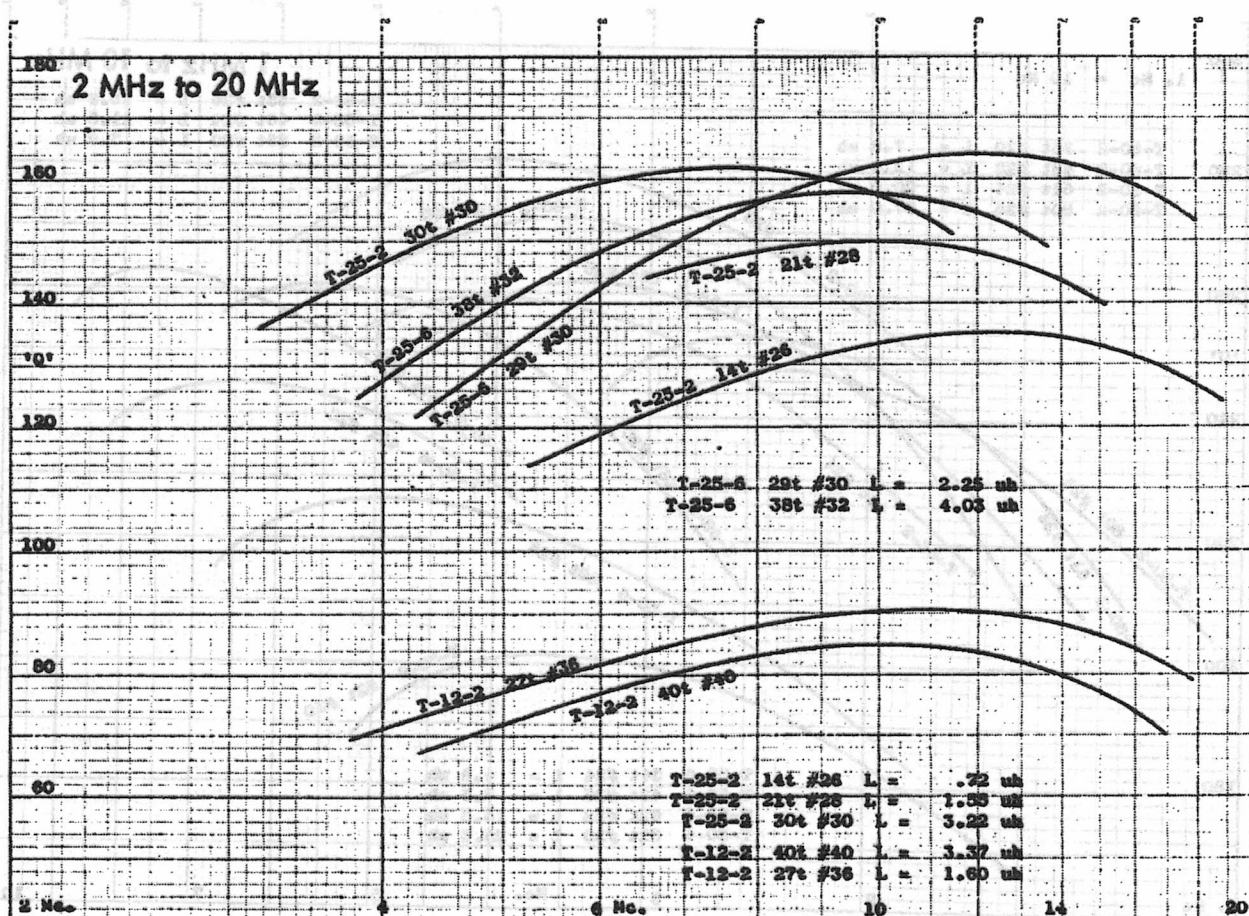
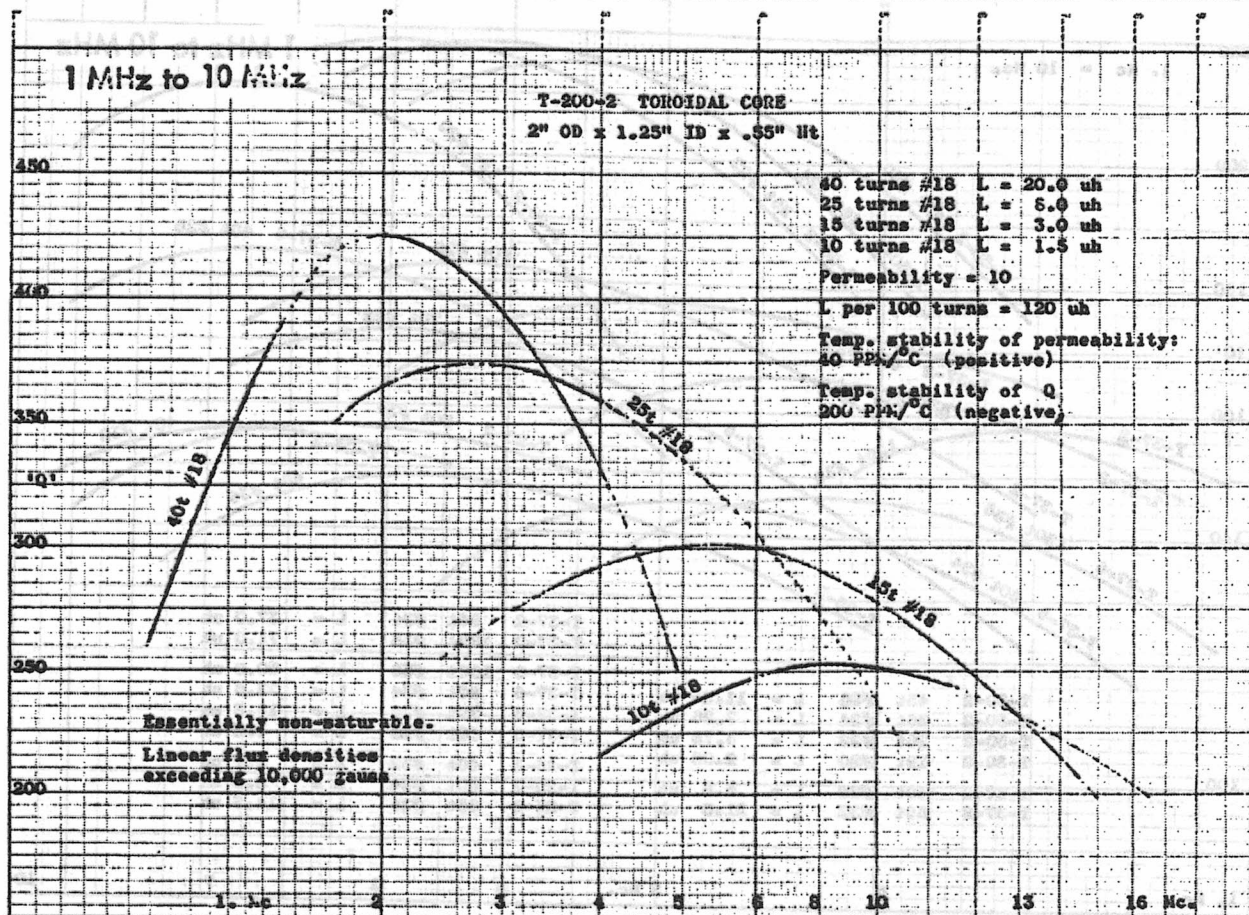
IRON-POWDER TOROIDAL CORES

Q—CURVES



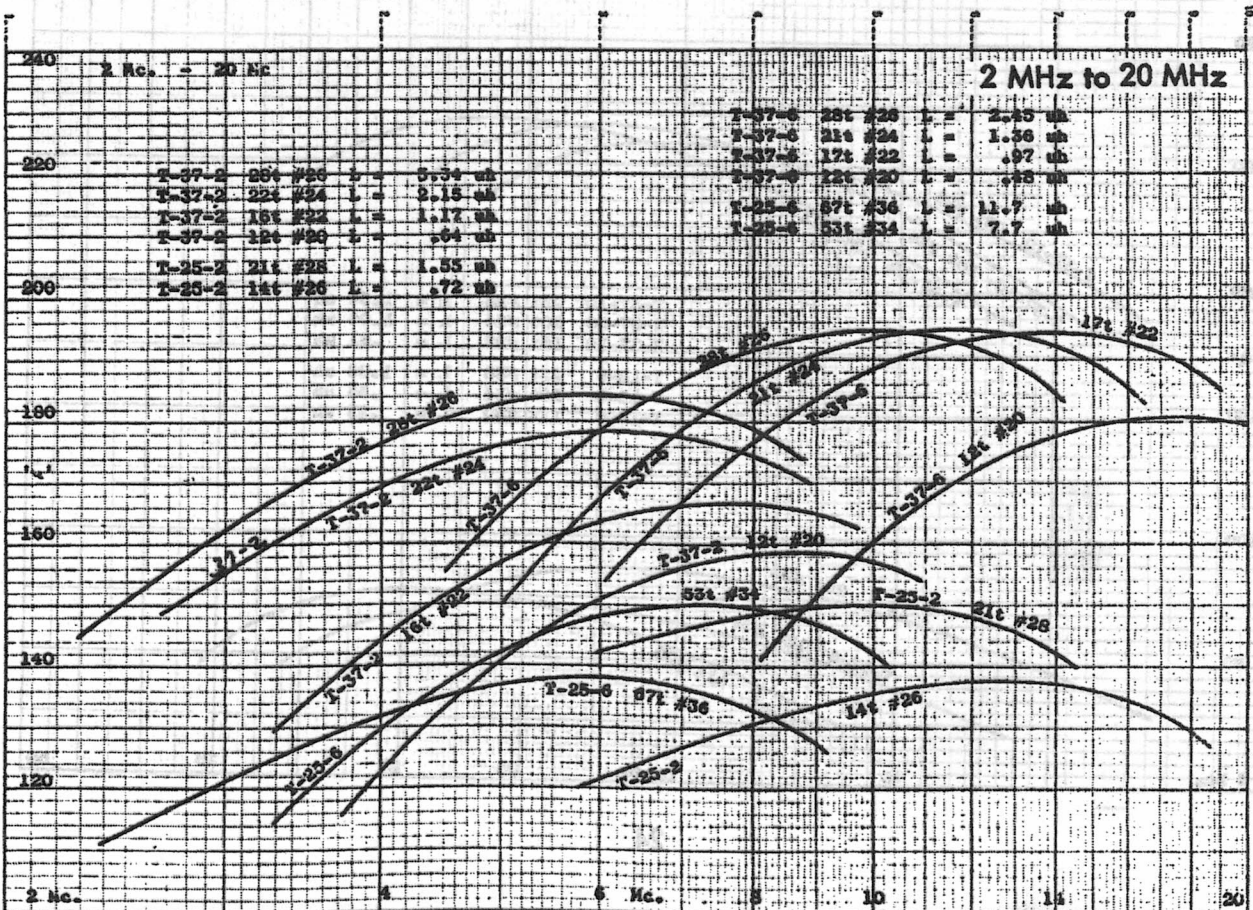
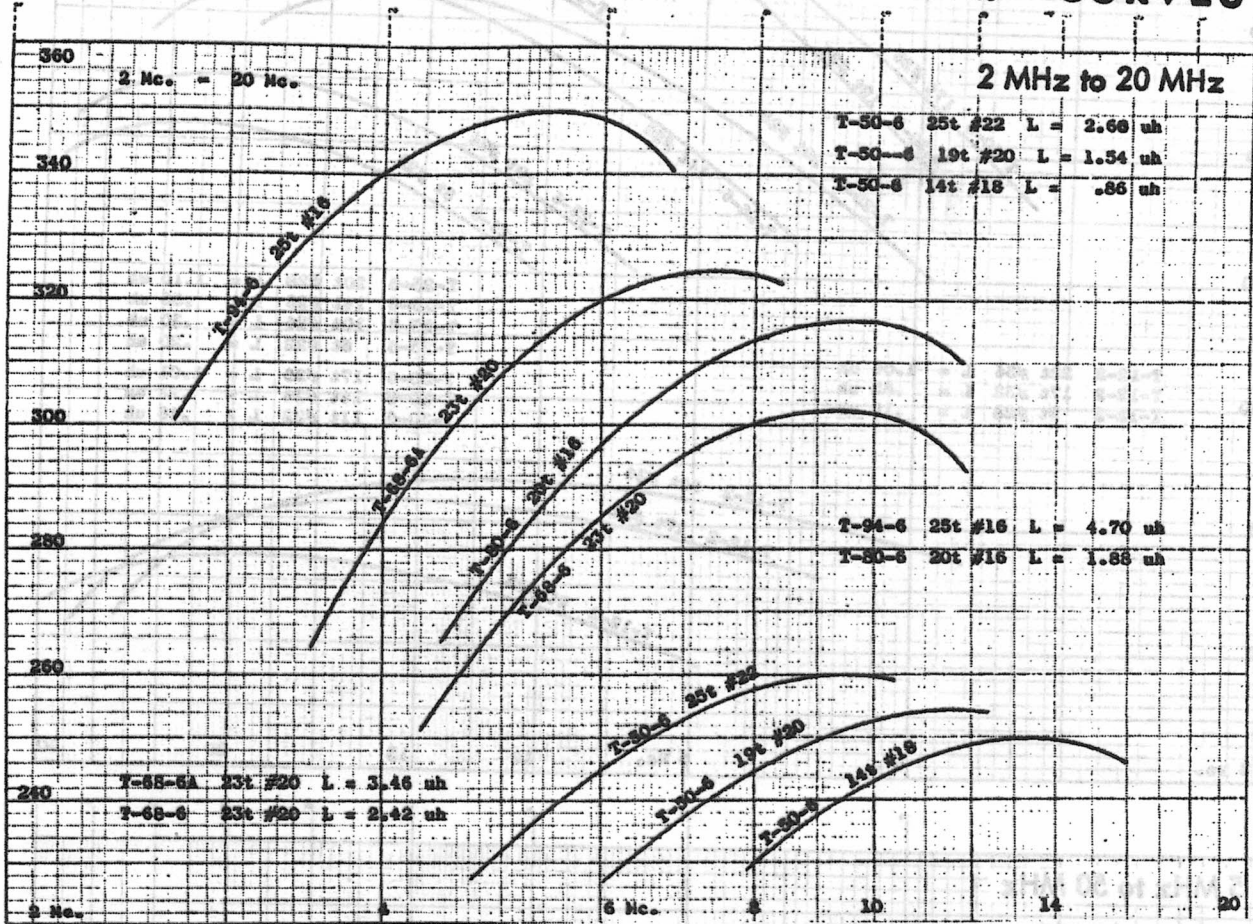
Q—CURVES

IRON-POWDER TOROIDAL CORES



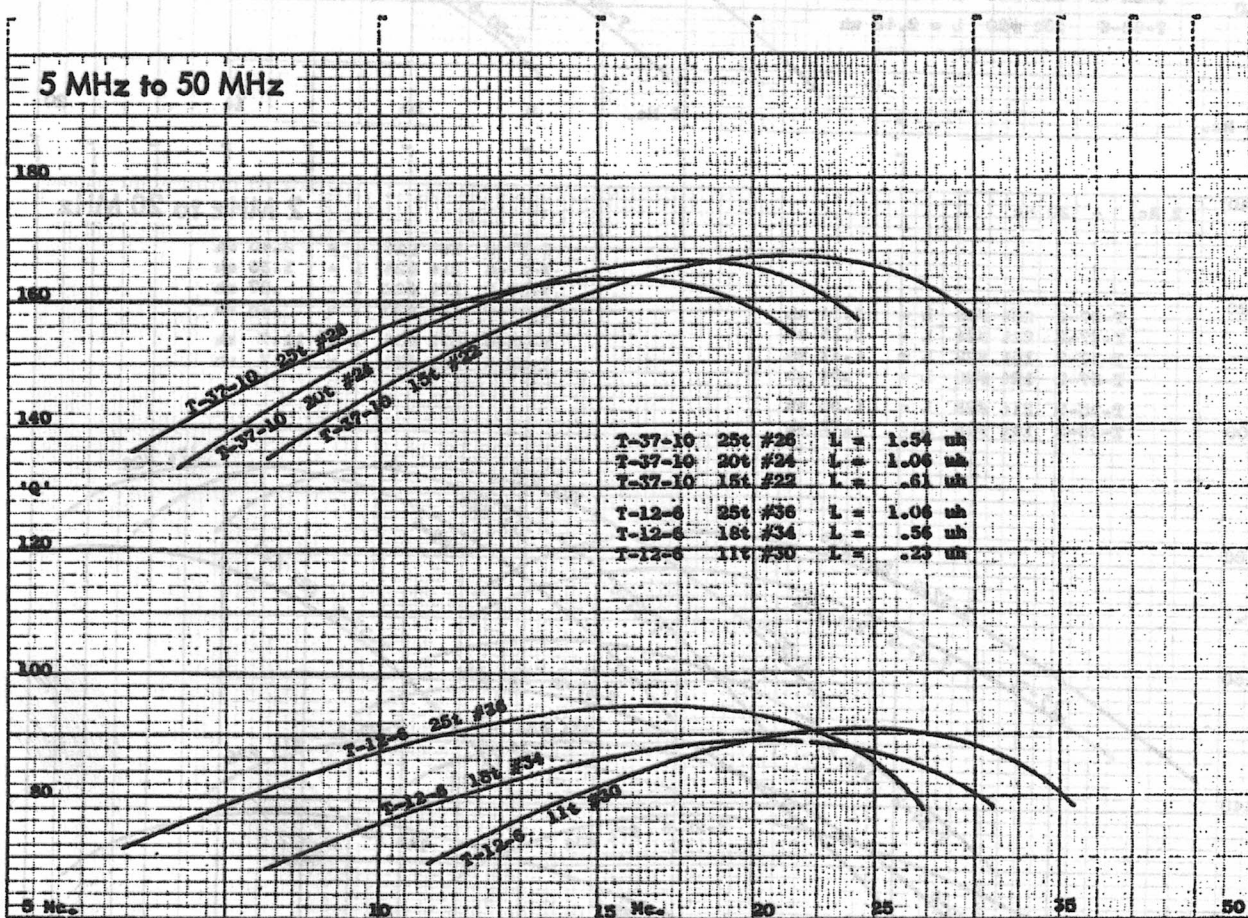
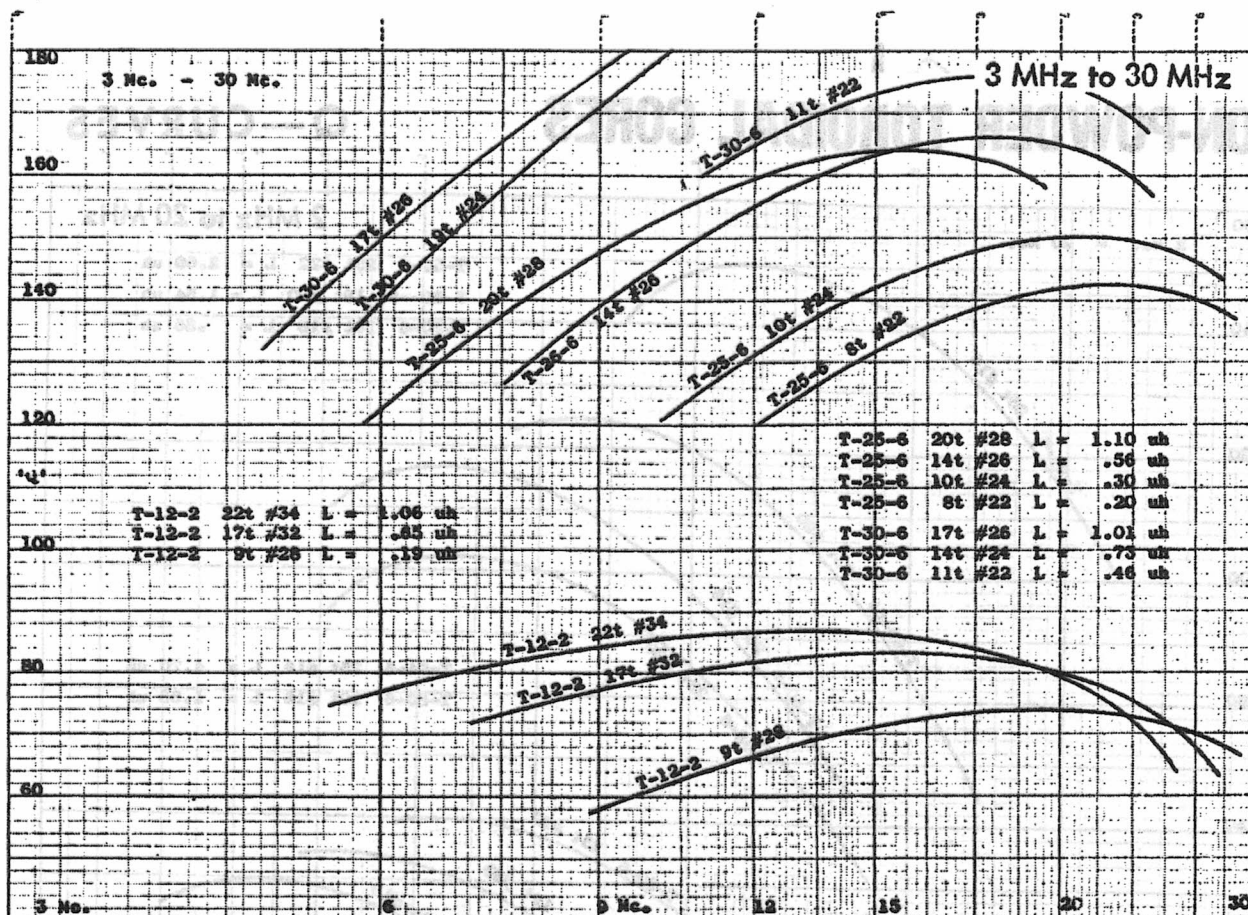
IRON-POWDER TOROIDAL CORES

Q—CURVES



Q—CURVES

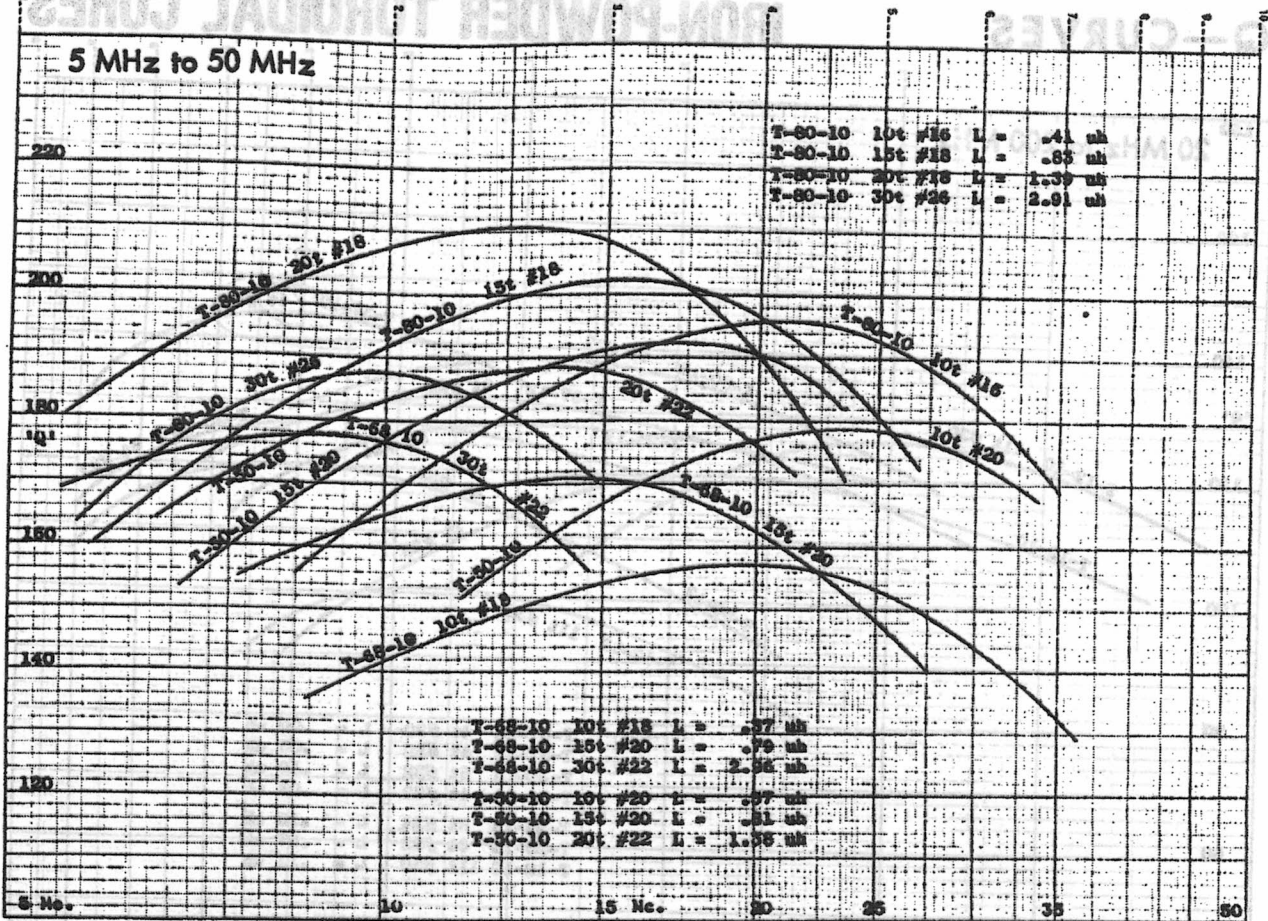
IRON-POWDER TOROIDAL CORES



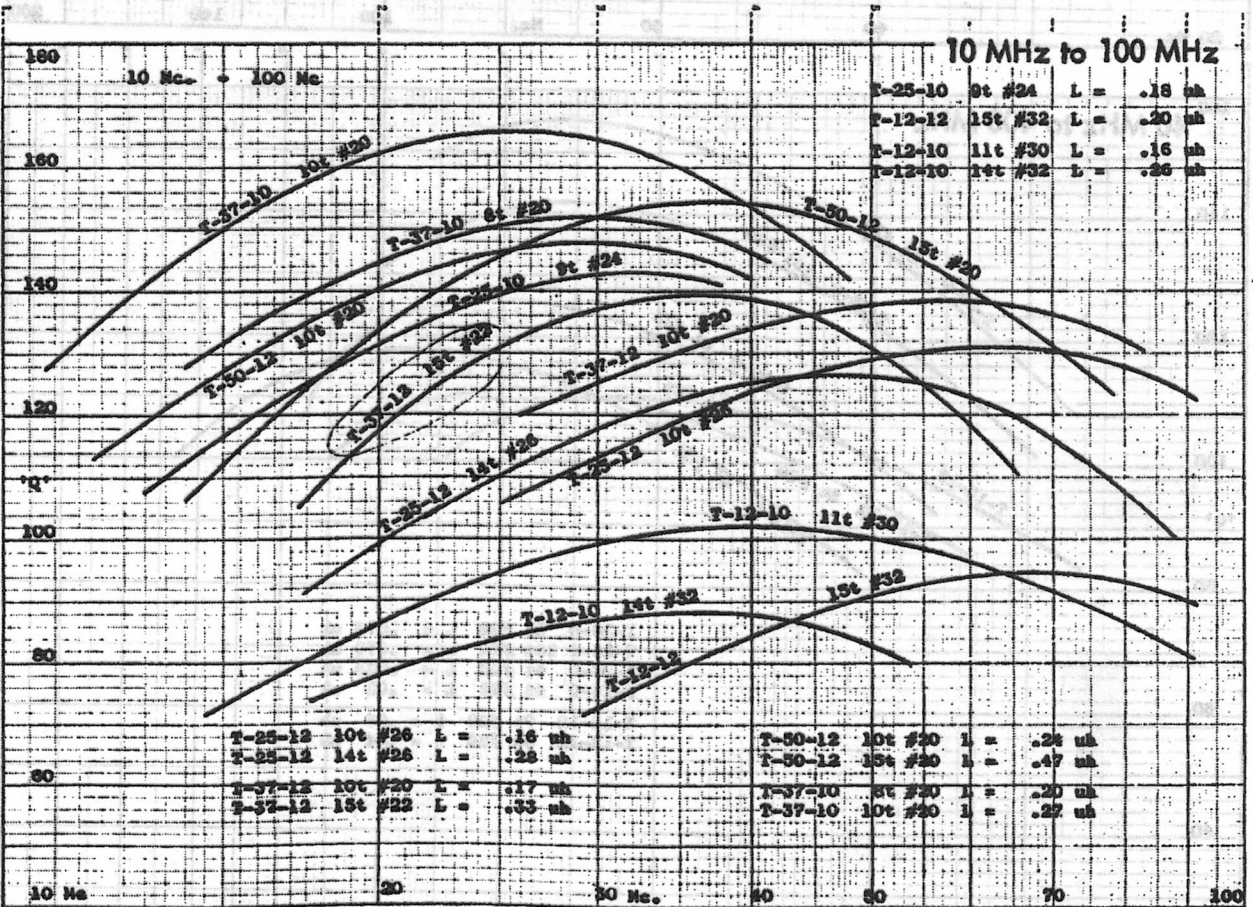
IRON-POWDER TOROIDAL CORES

Q-CURVES

5 MHz to 50 MHz



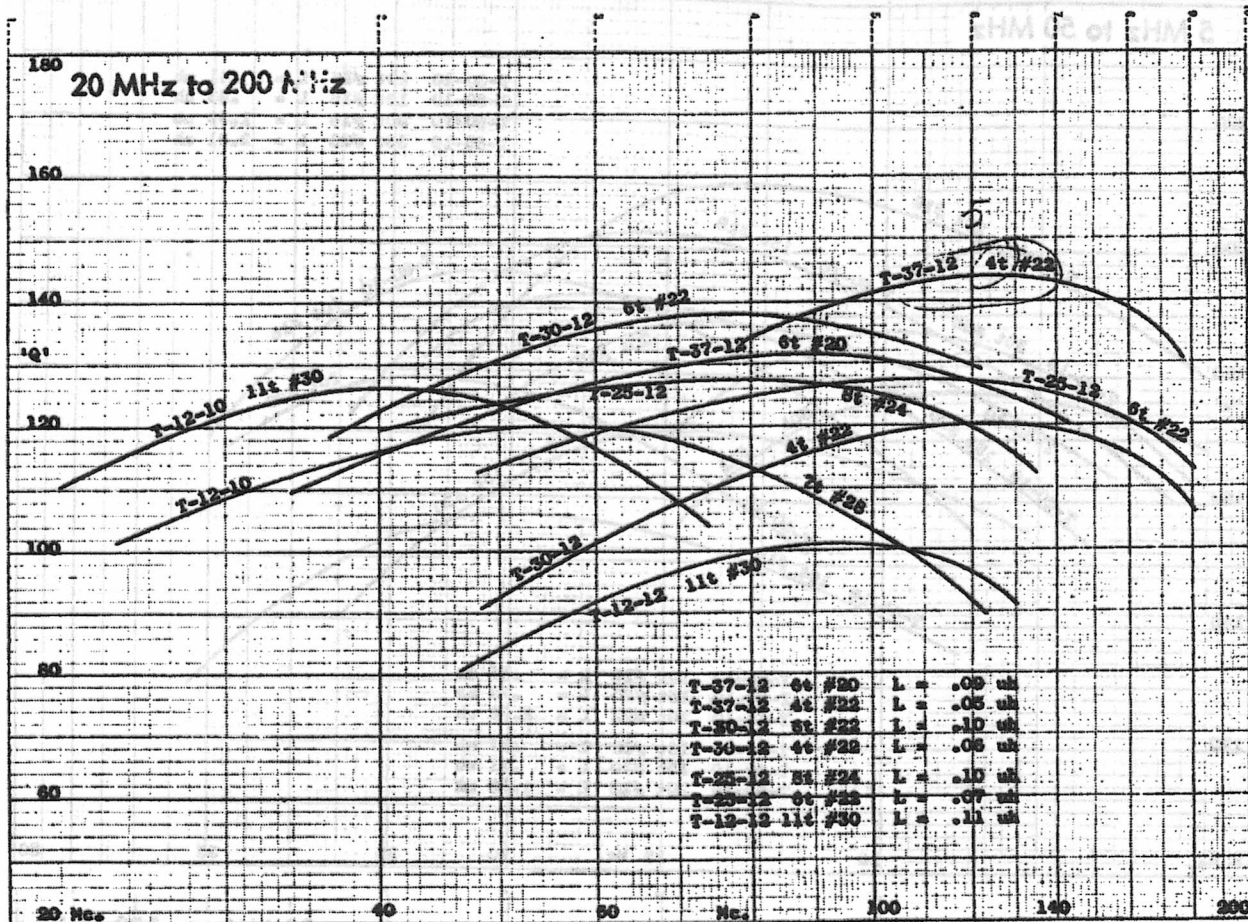
10 MHz to 100 MHz



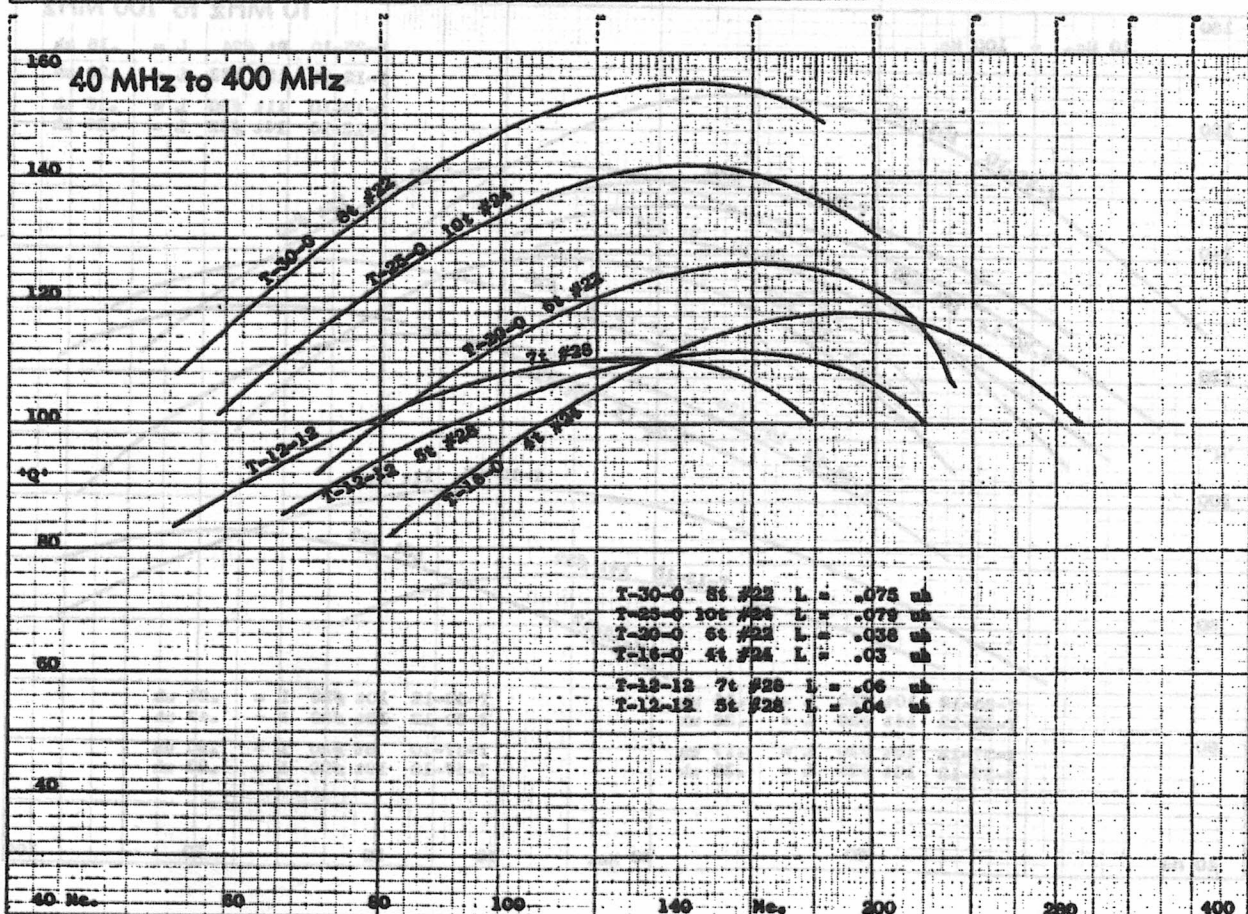
T37-12.
15 Wdg
0.7 mm.
≅ 36 Mc
≅ 0.32 μt

Q—CURVES

IRON-POWDER TOROIDAL CORES



105-10
T37
5 wires =
1.7 m
= 1.0



INDUCTANCE CHARTS

Iron Powder Toroids

IRON POWDER TOROIDAL CORES

MATERIAL #0 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	.19	.76	1.7	3.0	4.8	6.8	9.3	12	15	19	23	27	32	37
T-94	.10	.40	.90	1.7	2.7	3.8	5.2	6.8	8.6	10.	13	15	18	21
T-80	.08	.34	.77	1.4	2.1	3.0	4.2	5.4	6.9	8.5	10	12	14	-
T-68	.07	.30	.67	1.2	1.9	2.7	3.7	4.8	6.0	7.5	-	-	-	-
T-50	.06	.26	.57	1.0	1.6	2.3	3.1	4.1	-	-	-	-	-	-
T-37	.05	.20	.44	.7	1.2	-	-	-	-	-	-	-	-	-
T-25	.04	.18	.41	-	-	-	-	-	-	-	-	-	-	-
T-20	.03	.14	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.03	.12	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.03	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #1 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	3.2	13	29	52	81	117	159	208	263	325	393	468	549	637
T-94	1.6	6.4	14	25	40	57	78	102	130	160	194	230	270	304
T-80	1.2	4.6	10	18	28	41	56	73	93	115	139	166	194	-
T-68	1.2	4.6	10	18	28	41	56	73	93	115	139	166	194	-
T-50	1.0	4.0	9	16	25	36	49	64	-	-	-	-	-	-
T-37	.8	3.2	7	13	20	-	-	-	-	-	-	-	-	-
T-25	.7	2.8	6	-	-	-	-	-	-	-	-	-	-	-
T-20	.5	2.0	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.4	1.7	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.4	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL # 2 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	1.4	5	12	22	34	49	66	86	109	135	163	194	228	265
T-94	.8	3	8	13	21	30	41	54	68	84	101	120	131	142
T-80	.6	2	5	9	14	20	27	35	45	55	66	79	93	-
T-68	.6	2	5	9	15	21	29	38	48	59	-	-	-	-
T-50	.5	2	2	8	12	18	24	31	-	-	-	-	-	-
T-37	.4	2	4	6	10	-	-	-	-	-	-	-	-	-
T-25	.3	1	3	-	-	-	-	-	-	-	-	-	-	-
T-20	.3	1	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.2	-	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

AL 5
- AL 4

INDUCTANCE CHARTS

Iron Powder Toroids

IRON POWDER TOROIDAL CORES

MATERIAL #3 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	5	18	41	72	113	182	221	288	365	450	545	648	761	882
T-94	2	10	22	40	62	89	121	159	200	248	300	357	419	486
T-80	2	7	16	29	45	65	88	115	146	180	218	259	304	-
T-68	3	8	18	31	49	70	96	125	158	185	-	-	-	-
T-50	2	7	16	26	44	63	86	112	-	-	-	-	-	-
T-37	1	5	9	-	-	-	-	-	-	-	-	-	-	-
T-25	1	4	9	-	-	-	-	-	-	-	-	-	-	-
T-20	.9	4	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.6	2	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.6	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #6 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	1.1	5	10	19	30	42	57	74	94	116	140	167	196	227
T-94	.7	3	6	11	18	25	34	45	57	70	85	100	118	137
T-80	.5	2	4	7	11	16	22	29	36	45	54	64	76	-
T-68	.5	2	4	7	11	17	23	30	38	47	-	-	-	-
T-50	.4	2	3	6	10	14	20	26	-	-	-	-	-	-
T-37	.4	1	3	5	7	-	-	-	-	-	-	-	-	-
T-25	.3	1	2	-	-	-	-	-	-	-	-	-	-	-
T-20	.2	.8	1	-	-	-	-	-	-	-	-	-	-	-
T-16	.2	-	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #10 Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size>														
T-94	.6	2	5	9	15	21	28	37	47	58	70	84	98	113
T-80	.3	1	3	5	8	12	16	21	27	33	40	48	54	-
T-68	.3	1	2	5	8	12	16	20	26	32	-	-	-	-
T-50	.3	1	3	5	8	11	15	20	-	-	-	-	-	-
T-37	.3	1	2	4	6	-	-	-	-	-	-	-	-	-
T-25	.2	.8	2	-	-	-	-	-	-	-	-	-	-	-
T-20	.1	.6	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.1	.5	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.1	-	-	-	-	-	-	-	-	-	-	-	-	-

INDUCTANCE CHARTS

Iron Powder Toroids

IRON POWDER TOROIDAL CORES

MATERIAL #15

Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	4	14	31	55	86	124	169	221	279	345	417	497	583	676
T-94	2	8	18	32	50	72	98	128	162	200	242	288	338	392
T-80	2	7	15	27	43	61	83	109	138	170	206	245	287	-
T-68	2	7	16	29	45	65	88	115	146	180	-	-	-	-
T-50	1	5	12	22	34	49	66	86	-	-	-	-	-	-
T-37	1	4	8	14	23	-	-	-	-	-	-	-	-	-
T-25	1	3	8	-	-	-	-	-	-	-	-	-	-	-
T-20	.5	3	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.5	3	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.5	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #17

Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-94	.3	1	3	5	8	12	16	20	30	32	39	46	54	63
T-80	.2	.8	2	4	6	6	11	14	18	22	27	32	37	-
T-68	.2	.8	2	3	5	7	10	13	17	21	-	-	-	-
T-50	.2	.7	2	3	5	7	9	12	-	-	-	-	-	-
T-37	.1	.6	1	2	4	-	-	-	-	-	-	-	-	-
T-25	.1	.5	1	-	-	-	-	-	-	-	-	-	-	-
T-20	.1	.4	-	-	-	-	-	-	-	-	-	-	-	-
T-16	.08	.3	-	-	-	-	-	-	-	-	-	-	-	-
T-12	.07	-	-	-	-	-	-	-	-	-	-	-	-	-

IRON POWDER TOROIDAL CORES

MATERIAL #26

Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130	140
Size														
T-106	9	36	81	144	245	324	441	576	729	900	1089	1296	1521	1764
T-94	6	24	53	94	148	212	289	378	478	590	714	850	997	1156
T-80	5	18	41	72	113	162	221	288	365	450	545	648	761	882
T-68	4	17	38	67	105	151	206	269	340	420	508	605	710	823
T-50	3	13	29	51	80	115	157	205	259	320	387	461	541	627
T-37	2.7	11	25	44	69	135	176	223	-	-	-	-	-	-

Amidon Associates: 12033 Otsego Street, North Hollywood, California, 91607

INDUCTANCE CHART - LARGE SIZE IRON POWDERS

LARGE CORES

Inductance (uh) vs. Size, Material and Number of Turns

Turns>	10	20	30	40	50	60	70	80	90	100	110	120	130
Core Number													
T-400A-26	26	104	324	416	650	936	1274	1664	2106	2600	3146	3744	4394
T-400A-2	4	14	32	21	58	90	130	176	230	292	360	436	518
T-400-26	13	53	119	211	330	475	646	845	1069	1320	1597	1900	2231
T-400-2	2	7	17	27	46	67	91	118	150	185	224	266	313
T-300A-26	16	64	144	256	400	576	784	1024	1296	1600	1936	2304	2704
T-300A-2	2	9	20	36	57	82	118	246	185	228	276	328	385
T-300-26	8	33	74	132	06	297	404	528	668	825	998	188	1394
T-300-2	1	5	10	18	29	41	56	74	93	115	139	166	194
T-225A-26	16	64	144	256	400	576	784	1024	1296	1600	1936	2304	2704
T-225A-2	2	9	19	34	54	77	105	138	174	215	276	310	385
T-225-26	10	38	86	152	238	342	466	608	770	950	1150	1368	1607
T-225-2	1	5	11	19	30	43	59	79	97	120	145	173	203
T-225-3	4	17	38	68	106	153	208	272	344	425	514	612	718
T-225-6	1	4	9	16	25	36	49	64	81	100	121	144	169
T-200A-26	16	62	136	248	388	558	760	992	1256	1550	1875	2418	2619
T-200A-1	5	18	41	73	114	164	223	291	369	455	551	655	764
T-200A-2	2	9	19	35	55	78	107	140	177	218	264	314	368
T-200A-3	5	18	41	74	115	165	225	294	373	460	557	662	777
T-200A-6	2	7	16	29	45	65	88	115	146	180	218	259	304
T-200-26	9	36	81	143	224	322	439	573	725	895	1082	1289	1513
T-200-1	3	10	23	40	63	90	123	160	203	250	303	360	423
T-200-2	1	5	11	19	30	43	59	79	97	120	145	173	203
T-200-3	4	17	38	68	106	153	208	272	344	425	514	612	718
T-200-6	1	4	9	16	25	36	49	64	81	100	121	144	169
T-184-26	16	66	148	262	410	590	804	1049	1328	1640	1984	2362	2772
T-184-1	5	20	45	80	125	180	245	320	405	500	605	720	845
T-184-2	2	10	22	38	60	86	118	154	194	240	290	396	406
T-184-3	7	29	65	115	180	259	353	461	583	720	871	1039	1217
T-184-6	2	8	18	31	49	70	96	125	158	195	236	281	330
T-157-26	10	34	87	155	243	349	475	621	786	970	1174	1397	1639
T-157-1	3	13	29	51	80	115	157	205	259	320	387	461	541
T-157-2	1	6	13	22	35	50	69	90	113	140	169	202	237
T-157-3	4	17	38	67	105	151	206	269	340	420	508	605	710
T-157-6	1	5	10	18	29	41	56	74	93	115	139	166	194
T-157-15	4	14	32	58	90	130	176	230	292	360	436	518	608
T-130-26	8	31	71	126	196	283	385	502	636	785	950	1130	1327
T-130-1	2	8	18	32	50	72	98	128	162	200	242	288	334
T-130-2	1	4	10	18	28	40	54	70	89	110	133	158	186
T-130-3	4	13	36	56	88	127	172	224	284	350	424	504	592
T-130-6	1	4	9	15	24	35	47	61	78	96	116	138	162
T-130-15	3	10	23	40	63	90	123	160	203	250	303	360	423

IRON POWDER TOROIDAL CORES

For AC LINE FILTERS and DC CHOKES

For many years Iron Powder has been used as the core material for RF inductors and transformers when stability and high 'Q' are of primary concern. Because of the growing need for energy storage inductors for noise filtering, new materials have been developed for these applications.

High 'Q' inductors are no longer required, in fact low 'Q' actually helps damp high frequency oscillations. The #26 Iron Powder material is ideally suited for these applications since it combines low 'Q', good frequency response, and high energy capabilities.

Energy storage, expressed in microjoules, is calculated by multiplying one-half the inductance in uh times the current in amperes squared. The amount of energy that can be stored in a given inductor is limited either by saturation of the core material or temperature rise of the wound unit, resulting in copper loss and/or core loss.

In typical DC chokes, the AC ripple flux is normally small in comparison to the DC component. Since the DC flux does not generate core loss, our primary concern becomes saturation and copper loss. The DC saturation characteristics of the #26 material are shown in Fig. A on the following page.

Using this information, DC energy storage curves have been developed as shown in the chart on the 2nd following page. A table of energy storage limits vs. temperature rise is included in the chart. The table at the bottom of the page is for single layer winding.

In 60 Hz. line filter applications, the high frequency to be filtered falls into two categories: (1) Common-mode noise and (2) Differential-mode noise. The common-mode noise is in relation to earth ground and is common to both lines. Differential mode noise is the noise between the two lines.

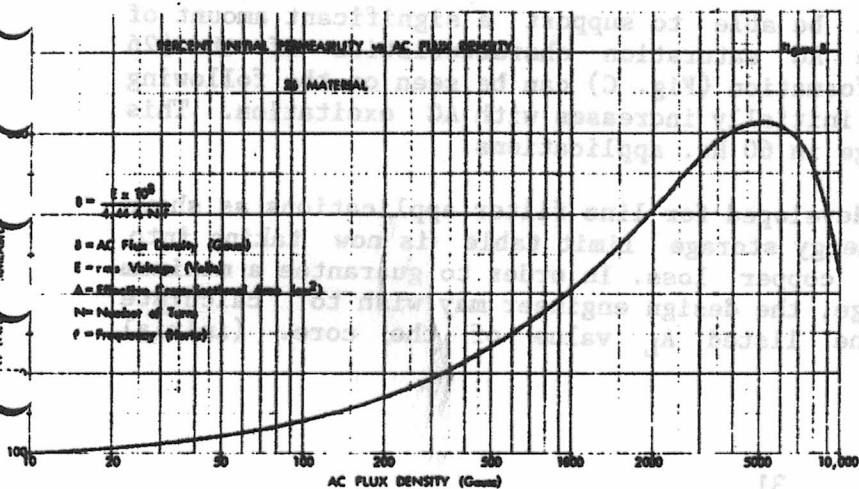
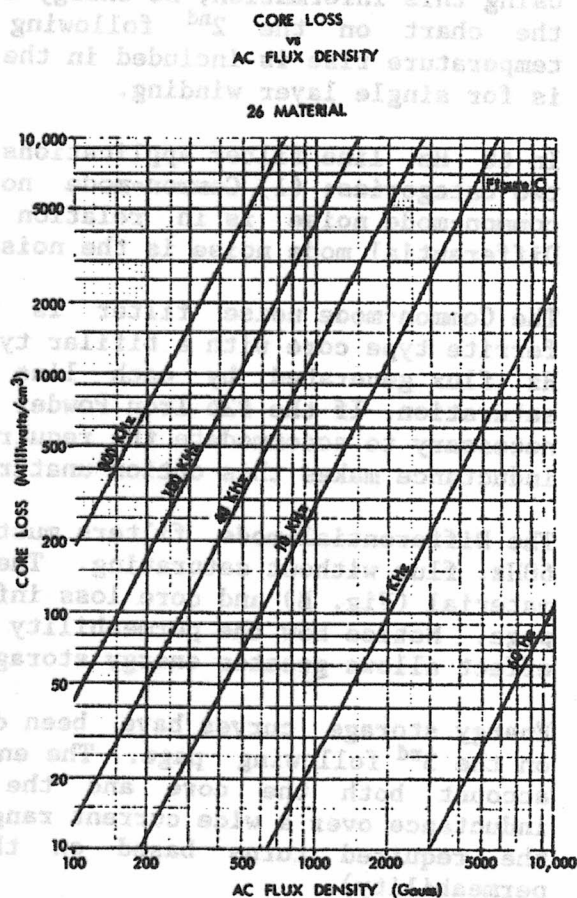
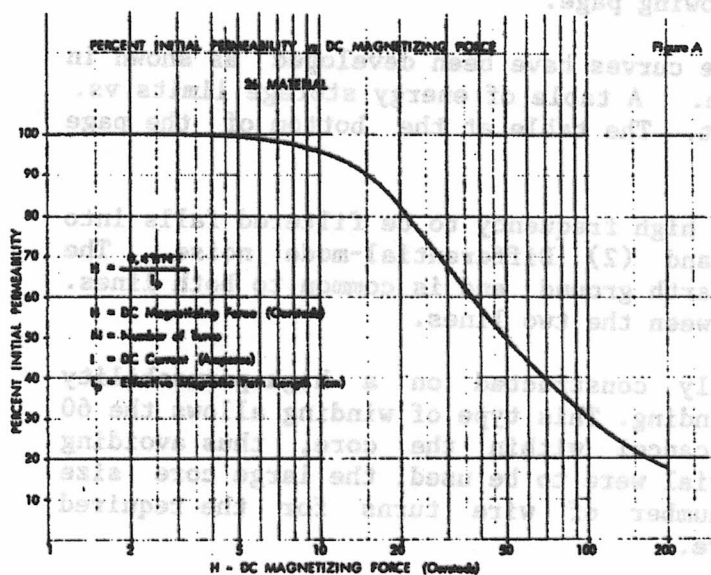
The Common-mode noise filter is usually constructed on a high permeability ferrite type core with a bifilar type winding. This type of winding allows the 60 Hz. flux generated by each line to cancel within the core, thus avoiding saturation. If the #26 Iron Powder material were to be used, the large core size necessary to accommodate the required number of wire turns for the required inductance makes this option unattractive.

The Differential-mode filters must be able to support a significant amount of 60Hz. flux without saturating. The AC saturation characteristics of the #26 material (Fig. B) and core loss information (Fig. C) can be seen on the following page. Notice how the permeability initially increases with AC excitation. This effect allows greater energy storage in 60 Hz. applications.

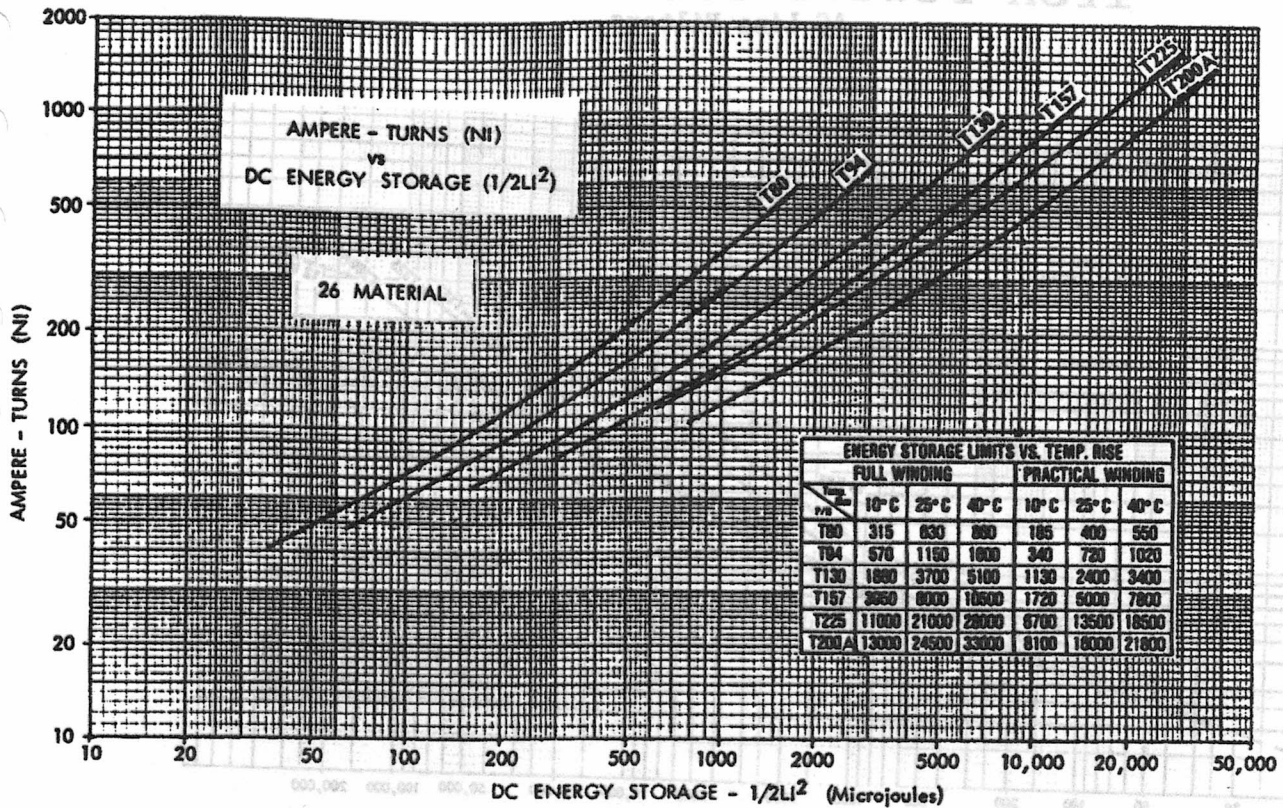
Energy storage curves have been developed for line filter applications as shown on the 3rd following page. The energy storage limit table is now taking into account both the core and the copper loss. In order to guarantee a minimum inductance over a wide current range, the design engineer may wish to calculate the required turns based on the listed A_L value of the core. (initial permeability).

Cores for DC Chokes and AC Line Filters

Material 26	Permeability 75			DC to 1 MHz (Low 'Q')			Yellow and White
Core number	O.D. (inches)	I.D. (inches)	Hgt. (inches)	I_e (cm)	A_e (cm) ²	V_e (cm) ³	A_L Value uh/100 turns
T-30-26	.307	.151	.128	1.83	.065	.119	325
T-37-26	.375	.205	.128	2.32	.070	.162	275
T-44-26	.440	.229	.159	2.67	.107	.286	360
T-50-26	.500	.303	.190	3.03	.121	.367	320
T-68-26	.690	.370	.190	4.24	.196	.831	420
T-80-26	.795	.495	.250	5.15	.242	1.246	450
T-94-26	.942	.560	.312	6.00	.385	2.310	590
T-106-26	1.060	.570	.437	6.50	.690	4.485	900
T-130-26	1.300	.780	.437	8.29	.730	6.052	785
T-157-26	1.570	.950	.570	10.05	1.140	11.457	970
T-184-26	1.840	.950	.710	11.12	2.040	22.685	1640
T-200-26	2.000	1.250	.550	12.97	1.330	17.250	895
T-200A-26	2.000	1.250	1.000	12.97	2.240	29.050	1525
T-225-26	2.250	1.405	.550	14.56	1.508	21.956	950
T-225A-26	2.250	1.485	1.000	14.56	2.730	39.749	1600
T-300-26	3.058	1.925	.500	19.83	1.810	35.892	800
T-300A-26	3.048	1.925	1.000	19.83	3.580	70.991	1600
T-400-26	4.000	2.250	.650	24.93	3.660	91.244	1300
T-400A-26	4.000	2.250	1.300	24.93	7.432	185.280	2600
T-520-26	5.200	3.080	.800	33.16	5.460	181.000	1460



Iron Powder Toroidal Cores DC Chokes

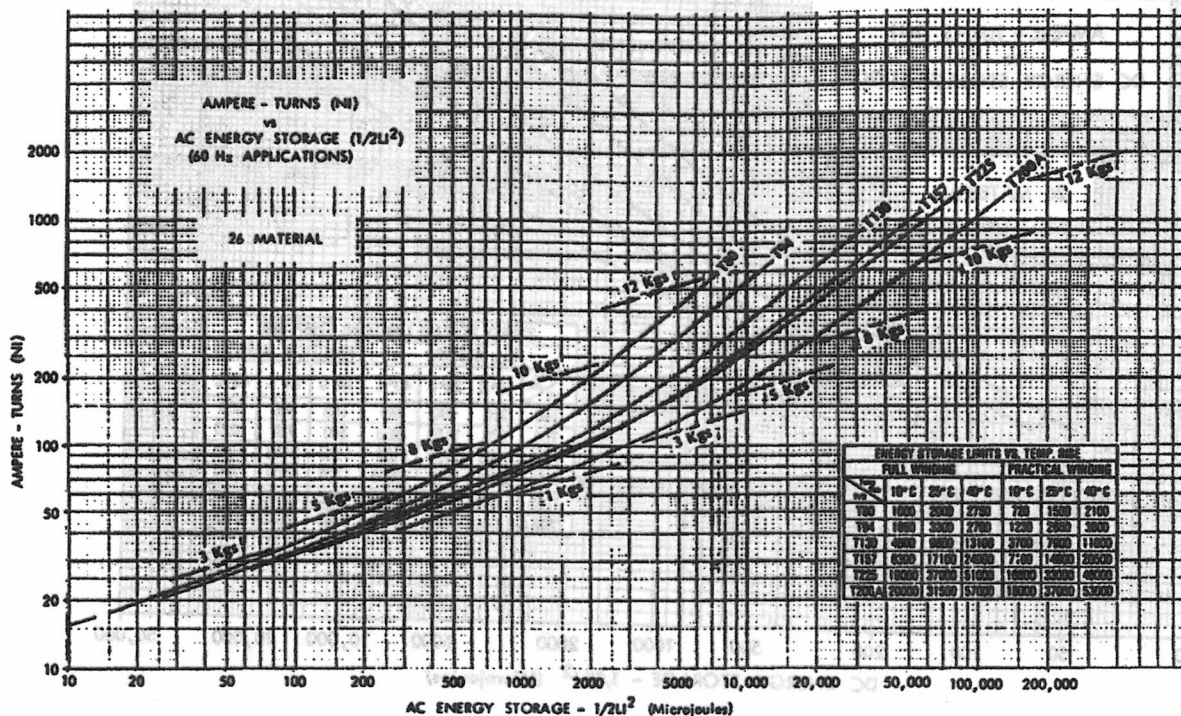


DC Choke Applications (single layer winding)

DC Amps >	1 Amp	2 Amps	4 Amps	6 Amps	10 Amps	15 Amps	20 Amps	30 Amps
Wire size >	28 AWG	24 AWG	21 AWG	19 AWG	16 AWG	14 AWG	12 AWG	10 AWG
Part\No								
T-37-26*	35 uh 41 turns	13.5 uh 27 turns	4.0 uh 15 turns	1.8 uh 10 turns	.8 uh 7 turns	.38 uh 5 turns	.16 uh 3 turns	.012 uh 1 turn
T-50-26*	92 uh 63 turns	29.0 uh 37 turns	11.3 uh 25 turns	5.5 uh 18 turns	2.1 uh 11 turns	1.1 uh 8 turns	.59 uh 6 turns	.36 uh 5 turns
T-80-26	380 uh 108 turns	130 uh 66 turns	51.3 uh 45 turns	27.8 uh 35 turns	11.2 uh 23 turns	5.7 uh 17 turns	3 uh 12 turns	1.3 uh 8 turns
T-94-26	650 uh 123 turn	220 uh 75 turns	87.5 uh 52 turns	47.2 uh 40 turns	20.0 uh 27 turns	10.2 uh 20 turns	5.3 uh 14 turns	2.6 uh 10 turns
T-130-26	1660 uh 173 turns	575 uh 107 turns	231 uh 75 turns	127 uh 58 turns	55.0 uh 40 turns	28.0 uh 30 turns	16.5 uh 23 turns	10.4 uh 17 turns
T-157-26	3200 uh 213 turns	1100 uh 122 turns	438 uh 93 turns	244 uh 73 turns	106 uh 50 turns	55.6 uh 38 turns	32 uh 29 turns	16.4 uh 22 turns
T-184-26*	5600 uh 213 turns	1950 uh 122 turns	788 uh 93 turns	439 uh 73 turns	190 uh 50 turns	99.6 uh 38 turns	57.5 uh 29 turns	29.3 uh 22 turns
T-225-26	8600 uh 317 turns	2300 uh 198 turns	938 uh 139 turns	528 uh 110 turns	230 uh 77 turns	127 uh 60 turns	72.5 uh 46 turns	40 uh 36 turns
T-300A-26*	22.4 mh 435 turns	7850 uh 272 turns	3120 uh 190 turns	1750 uh 151 turns	760 uh 105 turns	418 uh 82 turns	250 uh 63 turns	129 uh 44 turns
T-400A-26*	51.0 mh 507 turns	17.5 mh 317 turns	7120 uh 223 turns	4000 uh 176 turns	1760 uh 122 turns	951 uh 95 turns	550 uh 73 turns	293 uh 57 turns

Note: * Size not shown on above curve chart. ** Wire size based on Max. Temp. rise 40EO C.

Iron Powder Toroidal Cores AC Line Filters



60 Hz. AC Line Filter Applications (single layer winding)

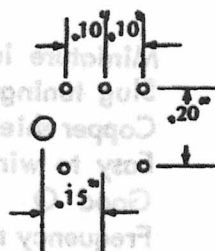
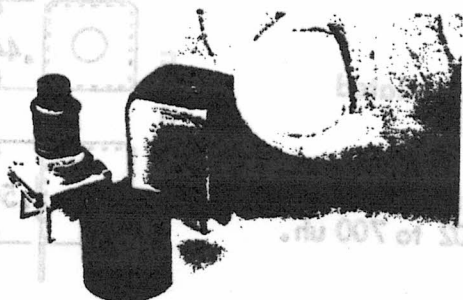
AC Amps >	1 Amp	2 Amps	4 Amps	6 Amps	10 Amps	15 Amps	20 Amps	30 Amps
Wire size >	28 AWG	24 AWG	21 AWG	19 AWG	15 AWG	13 AWG	11 AWG	9 AWG
Part\No								
T-37 -26*	130 uh 41 turns	50.0 uh 27 turns	15 uh 15 turns	6.7 uh 10 turns	2.4 uh 6 turns	1.1 uh 4 turns	.60 uh 3 turns	.07 uh 1 turn
T-50 -26*	460 uh 63 turns	150 uh 37 turns	58.8 uh 25 turns	26.1 uh 17 turns	9.4 uh 10 turns	4.2 uh 7 turns	2.4 uh 5 turns	1.0 uh 3 turns
T-80 -26	1600 uh 108 turns	550 uh 66 turns	213 uh 45 turns	94.4 uh 30 turns	34.0 uh 18 turns	15.1 uh 12 turns	8.5 uh 9 turns	3.8 uh 6 turns
T-94 -26	2899 uh 123 turns	950 uh 75 turns	375 uh 52 turns	156 uh 33 turns	56.0 uh 20 turns	24.9 uh 13 turns	14 uh 10 turns	6.2 uh 7 turns
T-130 -26	7200 uhh 173 turns	2500 uh 107 turns	1000 uh 75 turns	444 uh 50 turns	160 uh 30 turns	71.1 uh 20 turns	40 uh 15 turns	17.8 uh 10 turns
T-157 -26	13.6 mh 213 turns	4650 uh 139 turns	1810 uh 93 turns	806 uh 62 turns	290 uh 37 turns	129 uhh 25 turns	72.5 uh 18 turns	32.2 uh 12 turns
T-184 -26*	22 mh 213 turns	7750 uh 132 turns	3130 uh 93 turns	1390 uh 62 turns	500 uh 37 turns	222 uh 25 turns	125 uh 18 turns	56.6 uh 12 turns
T-225 -26	26 mh 317 turns	9000 uh 198 turns	3500 uh 139 turns	1940 uh 110 turns	700 uh 66 turns	311 uh 44 turns	175 uh 33 turns	77.8 uh 22 turns
T-300A -26*	84 mh 435 turns	29 mh 272 turns	11.2 mh 190 turns	6390 uh 151 turns	2360 uh 93 turns	1240 uh 72 turns	750 uh 56 turns	356 uh 40 turns
T-400A -26*	180 mh 507 turns	61 mh 317 turns	25.6 mh 223 turns	14.2 mh 176 turns	5300 uh 108 turns	2800 uh 83 turns	1650 uh 65 turns	800 uh 46 turns

Note: * Size not shown on above curve chart. ** Wire size based on Max. Temp. rise 40° C.

Iron Powder Shielded Coil Forms

Adjustable/ Slug Tuned

L-33 Coil Forms (Specify material)

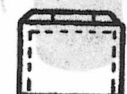


pin spacing

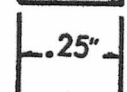
2X actual size



Shield Can

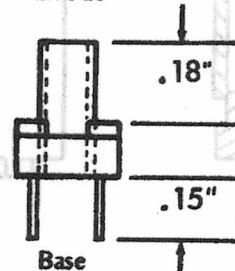


Cup Core

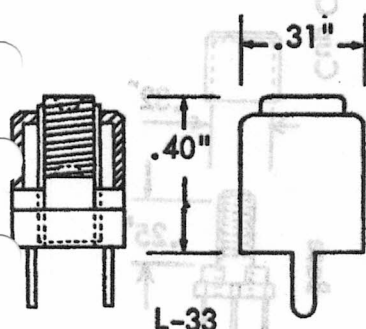


Threaded Core

2x size



Base



L-33

Sub miniature size

Slug tuning

Copper shield, tin plated

Easy to wind

Good Q

Freq. range 10 KHz - 200 MHz

Inductance range .08 - 180 uH

Part number	Frequency range (MHz)	A_L (uH/100t) at max L	L ratio max to min	Typical Winding (mid-freq.)			
				Wire	Turns	L(uH)	Qmax
L-33-1	0.30 - 1.0	76	1.7 - 1	3/44	75	42.5	80
L-33-2	1.00 - 10.0	68	1.5 - 1	9/44	40	10.9	90
L-33-3	0.01 - 0.5	80	1.8 - 1	3/44	150	180	70
L-33-6	10.00 - 50.0	60	1.5 - 1	26	7	0.36	100
L-33-10	25.00 - 100.0	54	1.4 - 1	26	5	0.18	120
L-33-12	50.00 - 200.0	48	1.3 - 1	26	3	0.08	130

Solid magnet wire may be substituted for the Litz wire, but somewhat lower Q may result.

Most efficient when tuning slug is set at maximum L.

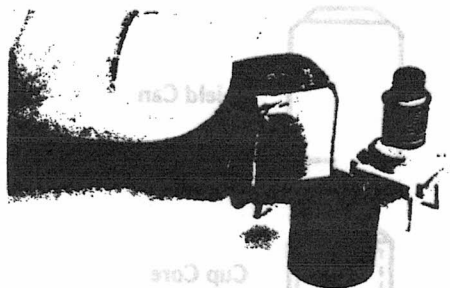
For tuning flexibility calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100 \sqrt{\frac{\text{desired 'L' (uH)}}{90\% A_L (\text{uH}/100 \text{ turns})}}$$

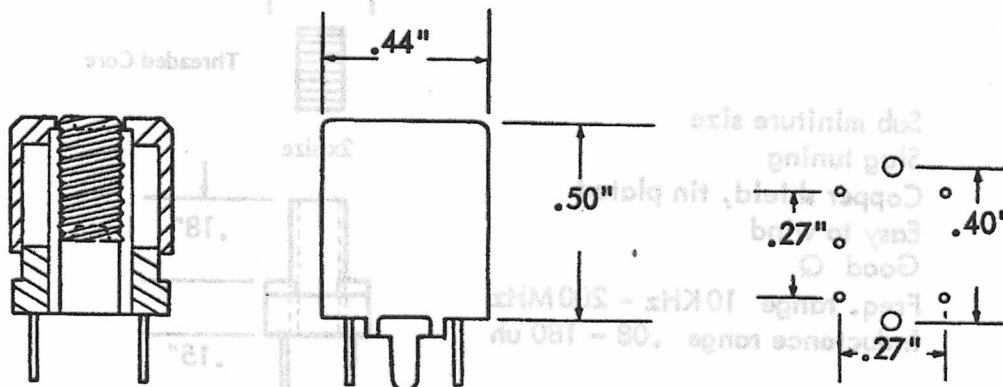
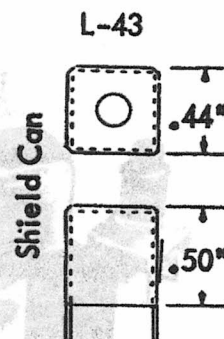
Iron Powder Shielded Coil Forms

Adjustable/ Slug Tuned

L-43 Coil Forms (Specify material)

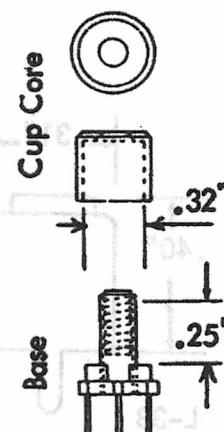


Miniature in size
Slug tuning
Copper shield can, tin plated
Easy to wind
Good Q
Frequency range .2 to 200 MHz.
Inductance range .02 to 700 uh.



L-43

pin spacing
2x actual size



Actual Size

Part number	Frequency range (MHz)	A_L (uh/100t) at max L	L ratio max to min	Typical Winding (mid-freq.)			
				Wire	Turns	L(uh)	Qmax
L-43-1	0.30 - 1.0	115	1.6 - 1	5/44	149	230	110
L-43-2	1.00 - 10.0	98	1.6 - 1	9/44	21	4.0	120
L-43-3	0.01 - 0.5	133	1.8 - 1	3/44	223	600	90
L-43-6	10.00 - 50.0	85	1.4 - 1	26	6	0.30	130
L-43-10	25.00 - 100.0	72	1.3 - 1	24	5	0.14	150
L-43-12	50.00 - 200.0	56	1.2 - 1	22	3	0.05	200

Solid magnet wire may be substituted for the Litz wire, but somewhat lower Q may result.

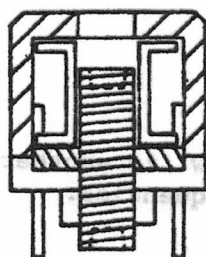
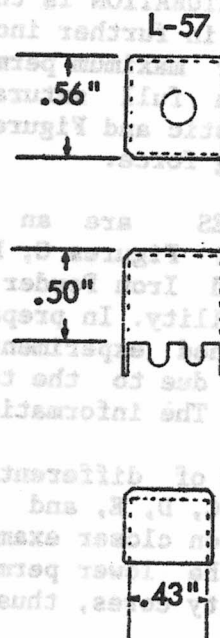
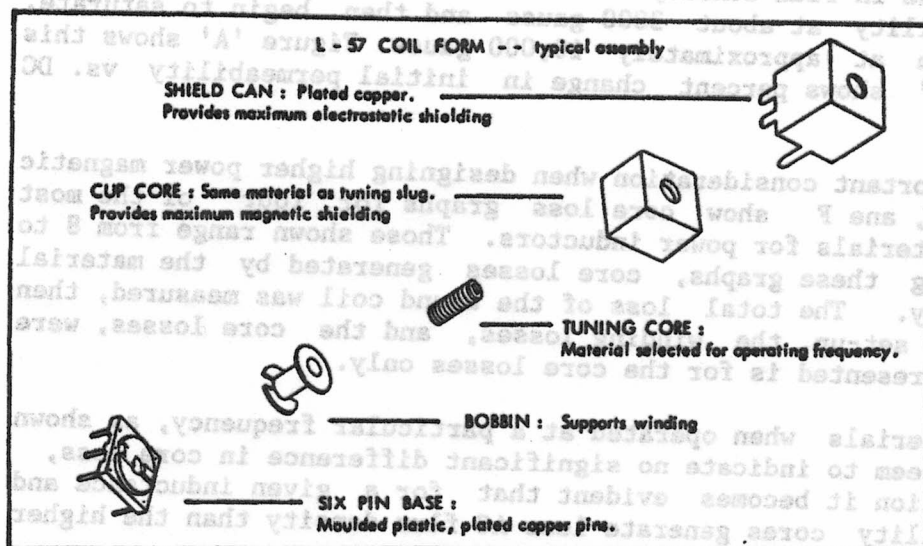
Most efficient when tuning slug is set at maximum L.
For tuning flexibility calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100 \sqrt{\frac{\text{desired 'L' (uh)}}{90\% A_L \text{ (uh/100 turns)}}$$

Iron Powder Shielded Coil Forms Adjustable/ Slug Tuned

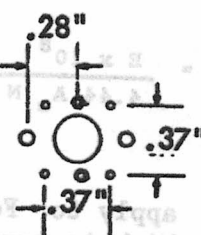
L-57 Coil Forms (Specify material)

Part Number	Frequency Range	A_L (uh/100 t) (at max. Q)	Color Code	Tuning Range
L-57-1	.30 MHz - 1.0 MHz	175 uh	Blue	3/1
L-57-2	1.00 MHz - 10.0 MHz	125 uh	Red	2/1
L-57-3	.01 MHz - .5 MHz	204 uh	Gray	3/1
L-57-6	10.00 MHz - 50.0 MHz	115 uh	Yellow	2/1
L-57-10	25.00 MHz - 100.0 MHz	100 uh	Black	2/1
L-57-12	50.00 MHz - 150.0 MHz	67 uh	Green	1.5/1

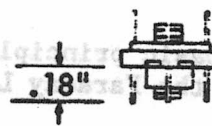


L-57

1. Available in materials 1, 2, 3, 6, 10, and 12
2. Can be tuned from both top and bottom
3. Furnished with six - pin base to accommodate center tapped coils.



pin spacing



Actual size

Most efficient when tuning slug is set at maximum L.
For tuning flexibility calculate so that slug will be about 90% maximum L when at operating frequency.

$$\text{Turns} = 100 \sqrt{\frac{\text{desired } L \text{ (uh)}}{90\% A_L \text{ value (uh)}}}$$

Iron Powder Core Selection for RF Power Applications

The next few pages are devoted to RF power applications and the selection of proper Iron Powder or Ferrite cores for power inductors and transformers operating in the 250 KHz to 5 MHz frequency range.

POWER applications of Iron Powder cores require special considerations. A common misconception is that core saturation is the primary limiting factor when selecting a core for high RF power application. Equally important is the degree of temperature rise of the wound unit. Temperature rise is the result of both core losses and winding losses. In fact, excessive temperature rise is quite often the primary limiting factor in high power applications, especially at frequencies above 1 MHz. Continuous duty operation of course will require a more conservative design as opposed to intermittent operation.

MAGNETIC SATURATION is the point at which the increase in magnetization force does not result in further increase in flux density. Carbonyl Iron Powder cores typically reach their maximum permeability at about 3000 gauss and then begin to saturate. They reach full saturation at approximately 10,000 gauss. Figure 'A' shows this characteristic and Figure 'B' shows percent change in initial permeability vs. DC magnetizing force.

CORE LOSSES are an important consideration when designing higher power magnetic components. Figures C, D, E, and F show core loss graphs for four of the most widely used Iron Powder materials for power inductors. Those shown range from 8 to 25 permeability. In preparing these graphs, core losses generated by the material were obtained experimentally. The total loss of the wound coil was measured, then the losses due to the test set-up, the winding losses, and the core losses, were separated. The information presented is for the core losses only.

COMPARISON of different materials when operated at a particular frequency, as shown in charts C, D, E, and F, seem to indicate no significant difference in core loss, however upon closer examination it becomes evident that for a given inductance and voltage, the lower permeability cores generate less AC flux density than the higher permeability cores, thus less core loss.

FARADAY LAW:
Version 1

$$B_{\max} = \frac{E \times 10^8}{4.44 A_e N f}$$

E = Applied RMS voltage (volts)
 A_e = Cross-sectional area (cm²)
 N = Number of winding turns
 f = Frequency in Hertz.

The above basic principles apply to Ferrite type cores as well. Below is another version of the Faraday Law which is more useful when working with RF frequencies.

FARADAY LAW:
Version 2

$$B_{\max} = \frac{E_{pk} \times 10^2}{4.44 f N A_e}$$

E_{pk} = Applied peak voltage (volts)
 A_e = Cross-sectional area (cm²)
 N = Number of winding turns
 f = Frequency (MHz.)

Fig. 'G' shows the power dissipation (mm/cc) of several sizes of Iron Powder cores in relation to temperature rises of 10°C, 25°C, and 40°C. The same chart gives the power rating of several sizes of #2 Iron Powder cores for 25°C temperature rise operating at 1 MHz. Physically small parts can dissipate more power per volume unit than the physically larger parts.

Iron Powder Core Selection for RF Power Applications

Fig. 'H' shows 'skin effect' vs. frequency and wire size. For example: the chart shows that a conductor larger than 35 AWG, when carrying a frequency of 1 MHz, will not be fully utilized, and thus will have an increased AC resistance. A multi-strand 'Litz' wire can be very useful for frequencies up to 1 MHz. but begin to lose effect above 1 MHz.

FIG. 'I' shows maximum voltage as a function of inductance (inductive reactance) for various Iron Powder core sizes in the #2 material at a frequency of 1 MHz. and for a temperature rise of 25°C due to core losses. Example: Select a core for a transformer requiring 100 ohms of primary inductive reactance, and capable of supporting 200 volts RMS. Fig. 'I' graph shows that 100 ohms of reactance is equal to 15.9 uh and that a T-157 size core will be required.

FIG. 'J' shows a similar set of curves to the above, except based on current as a function of inductance. Similar graphs for other frequencies and other core materials are available upon request. Example: An application requires 10 uh and the AC current level is 1 ampere, operating at 1 MHz. Fig. 'J' graph shows that a T-68 size core will be required. Also, referring back to Fig. 'I', this condition corresponds to a voltage drop across the coil of about 70 volts RMS.

TEMPERATURE RISE formula will provide a reasonable approximation for the temperature rise in a free standing air. For other environments, such as moving air or an enclosed case, allowances will have to be made. Long term operation of Iron Powder cores above 100°C can cause a permanent reduction of both 'Q' and inductance. The heat dissipated by a transformer will generate a temperature rise. This can be expressed in milli-watts per cubic centimeter as a function of peak AC flux density.

$$\text{Temp. Rise (°C)} = \left[\frac{\text{Power Dissipation (Milliwatts)}}{\text{Surface Area (cm}^2\text{)}} \right] .833$$

CONCLUSION: Power rating of a core can be defined as the product of the current flowing in the conductor and the voltage drop across the coil, for a given temperature rise due to core loss. This product is independent of the number of turns wound on the core.

For a QUICK EVALUATION, select a core you think will do the job and calculate the $B_{\max}$ with the Faraday formula. When power dissipation is known, the temperature rise can be calculated with the above temperature formula. If the temperature rise exceeds 75°C when used intermittently, or more than 50°C if used continuously, it will be necessary to select a larger core and/or larger AWG wire.

FERRITE core loss curves as well as maximum flux density figures for Ferrite materials will be found in the Ferrite section near the end of this booklet.

ADDITIONAL loss curves for a specific combinations of core size, core material and frequency are available upon request. Specify (1) Core size, (2) core material, and (3) frequency at which it is to be used.

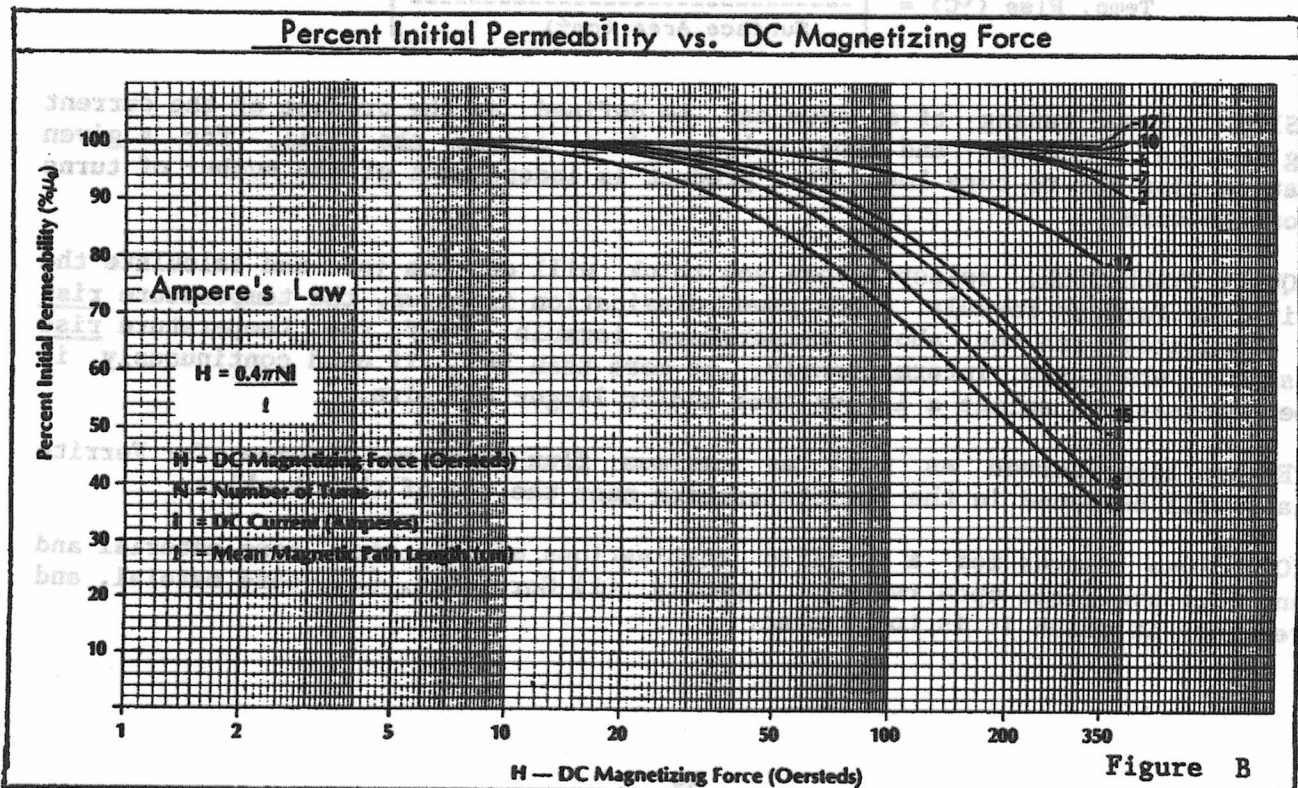
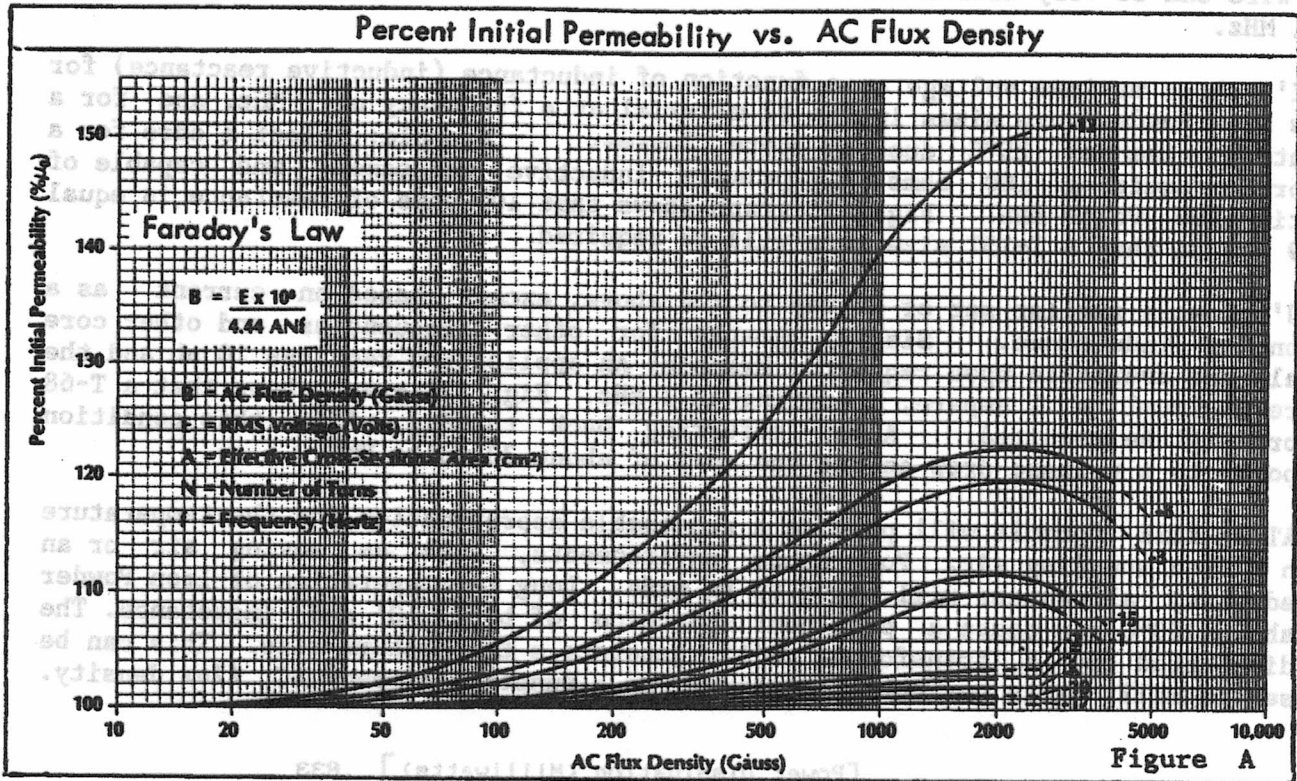
Iron Powder Materials

SATURATION and FLUX DENSITY

It is rather impractical to state that a certain size core will handle a given amount of power. Several factors are involved, most of which are variable according to operating conditions.

Core losses are minimal at the lower levels, but increase significantly as the flux density increases. High core losses will cause heating, which in turn will affect the saturation point.

Maximum flux density can be calculated for a given set of operating conditions with the use of FARADAY'S LAW and AMPERE'S LAW, both of which are shown below.



Core Loss vs. AC Flux Density

Iron Powder #6 Material
Permeability 8

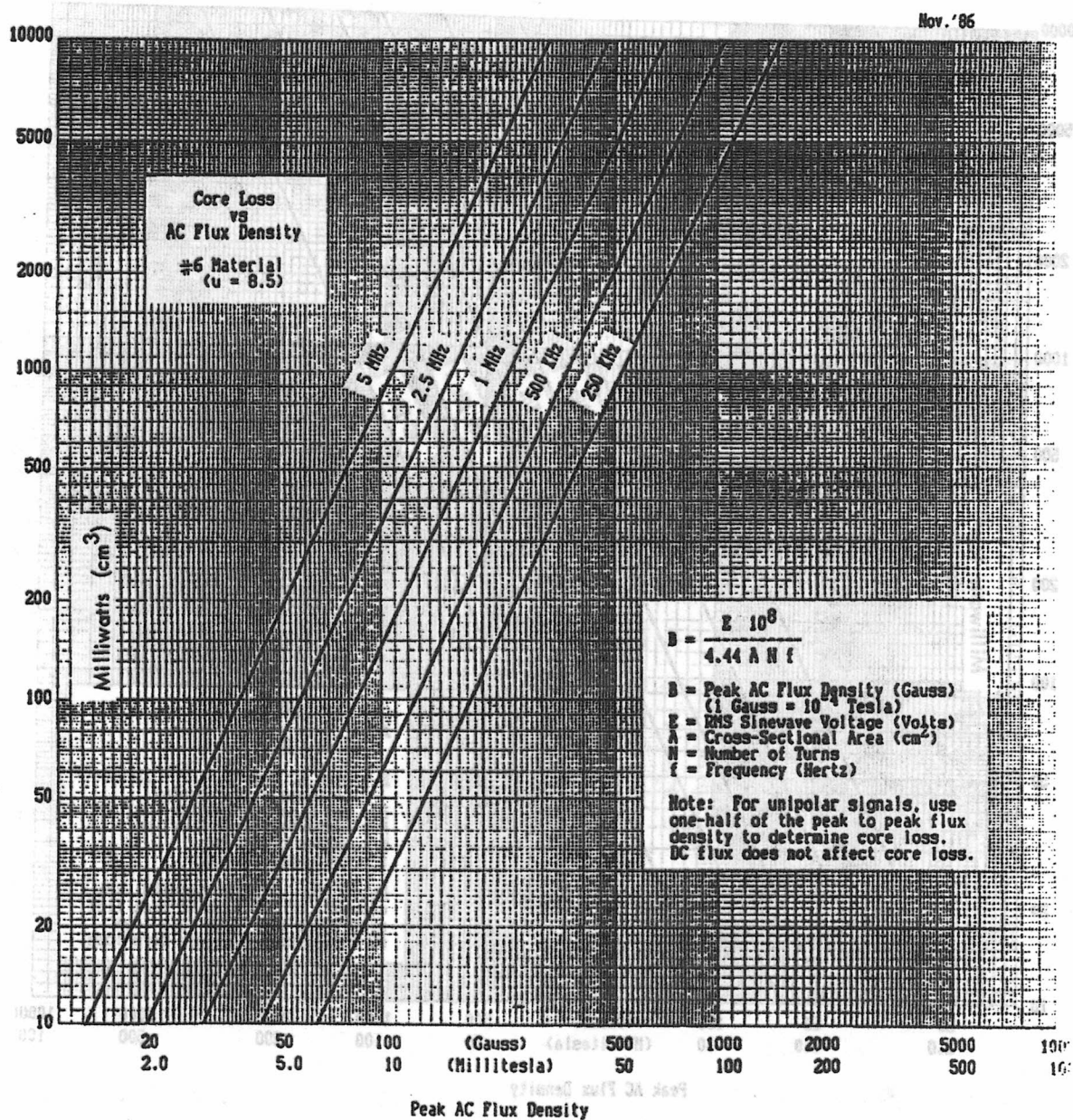


Figure C

Core Loss vs. AC Flux Density

Iron Powder #2 Material

Permeability 10

Nov. '86

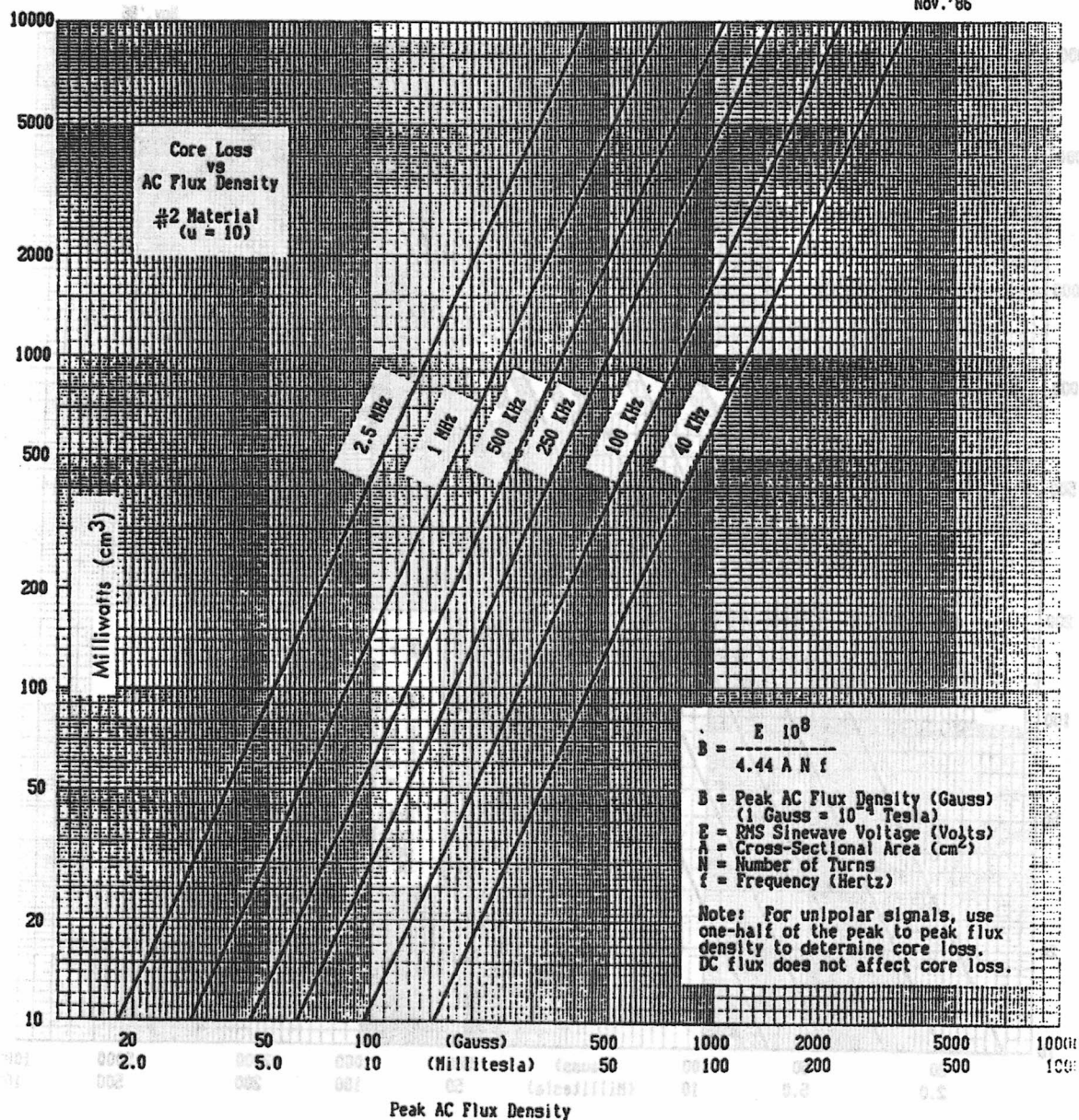


Figure D

Core Loss vs. AC Flux Density

Iron Powder #1 Material
Permeability 20

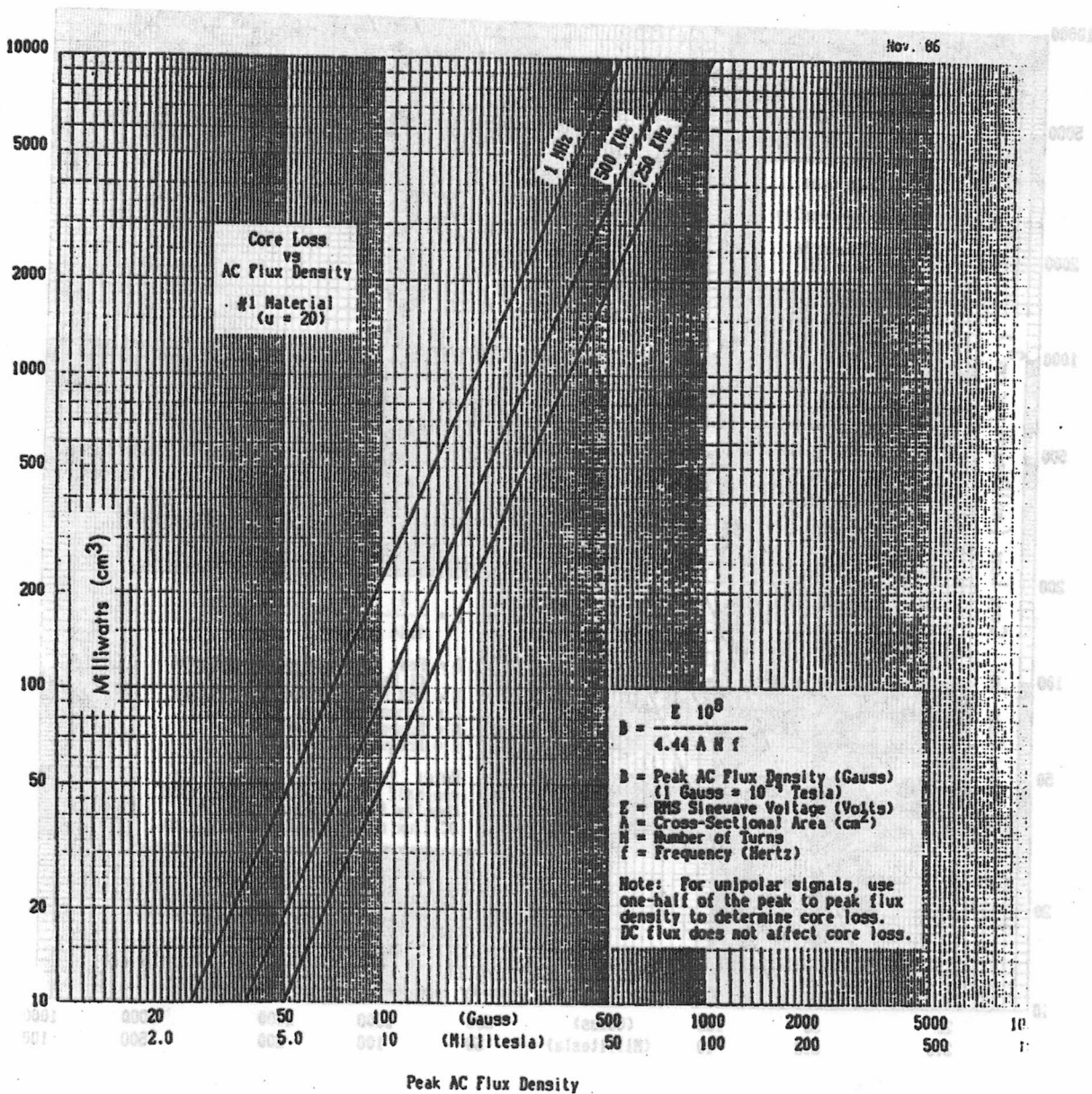


Figure E

Core Loss vs. AC Flux Density

Iron Powder #15 Material
Permeability 25

Nov. '86

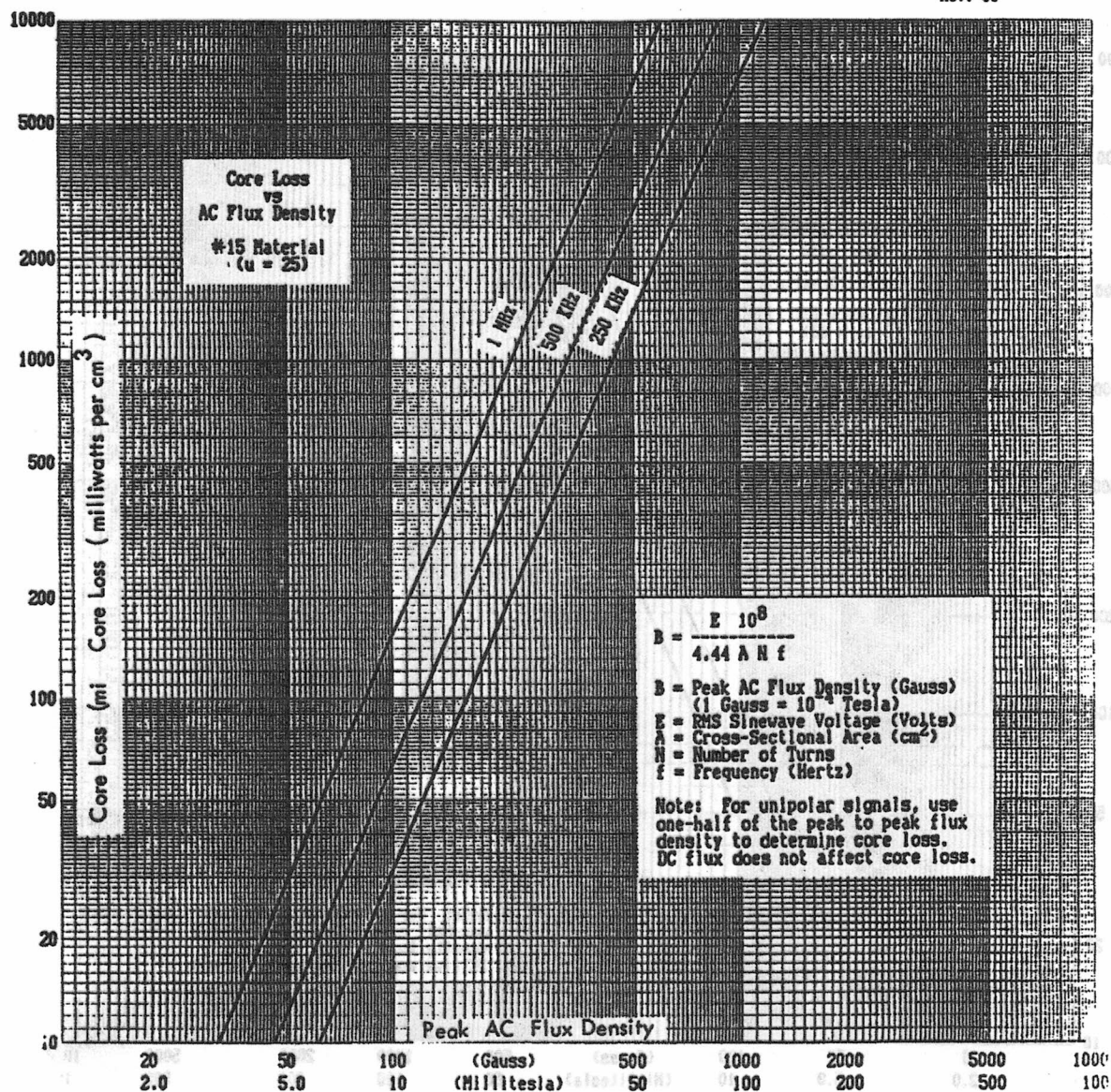


Figure F

Power Dissipation vs. Temperature Rise

Power Dissipation (mw/cc) as a function of temperature rise				Power rating for 25°C temp. rise due to core loss 2 Material, Freq. 1 MHz.	
Core Size	10°C	25°C	40°C	Core Size	Watts
T- 30	400	1148	2026	T- 30	24
T- 37	412	1170	2065	T- 37	26
T- 44	310	884	1556	T- 44	37
T- 50	307	874	1535	T- 50	49
T- 68	234	664	1167	T- 68	88
T- 80	212	602	1056	T- 80	125
T- 94	160	454	802	T- 94	160
T-106	114	322	566	T-106	236
T-130	117	331	582	T-130	331
T-157	94	266	468	T-157	515
T-200	87	260	436	T-200	794
T-300	62	186	327	T-300	1127
T-400	43	130	228	T-400	2108

Figure G

Skin Effect vs. Frequency and Wire Size

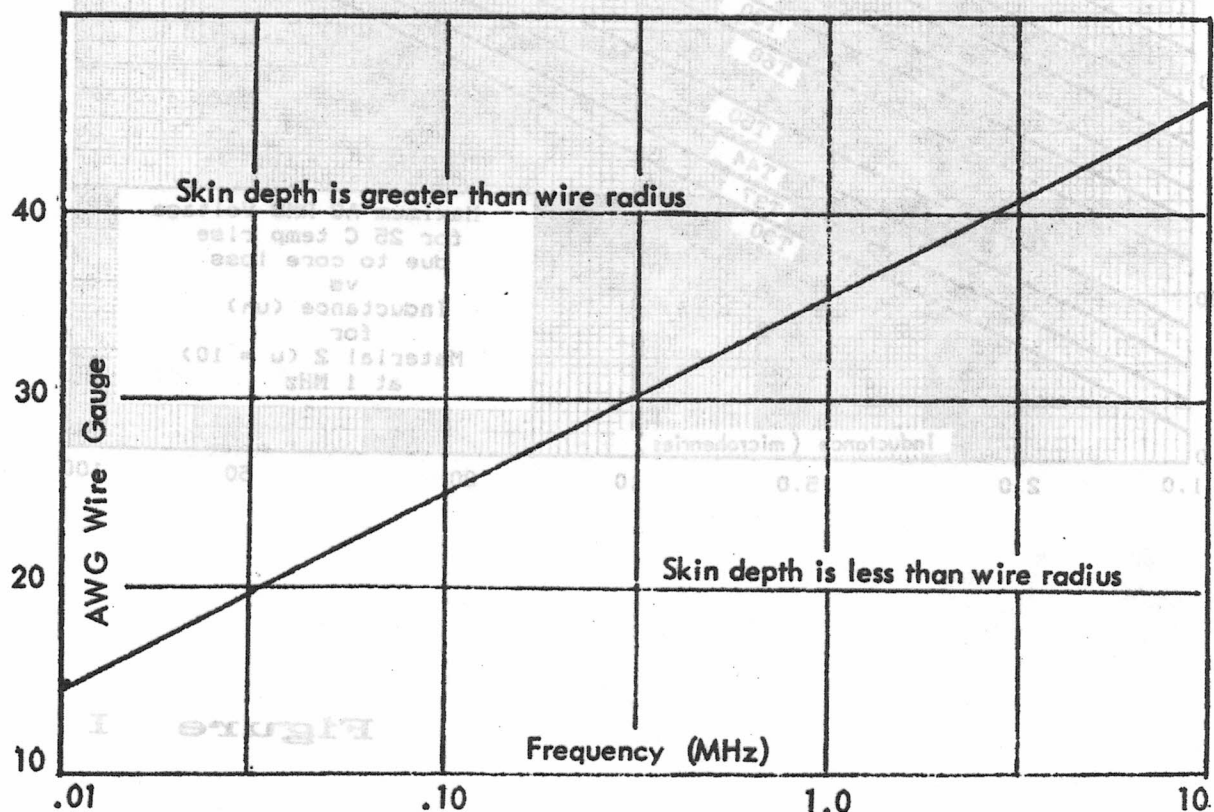


Figure H

Power Dissipation vs. Temperature Rise

AC RMS Voltage For 25°C temperature rise at 1 MHz

Iron Powder Material #2 Permeability 10

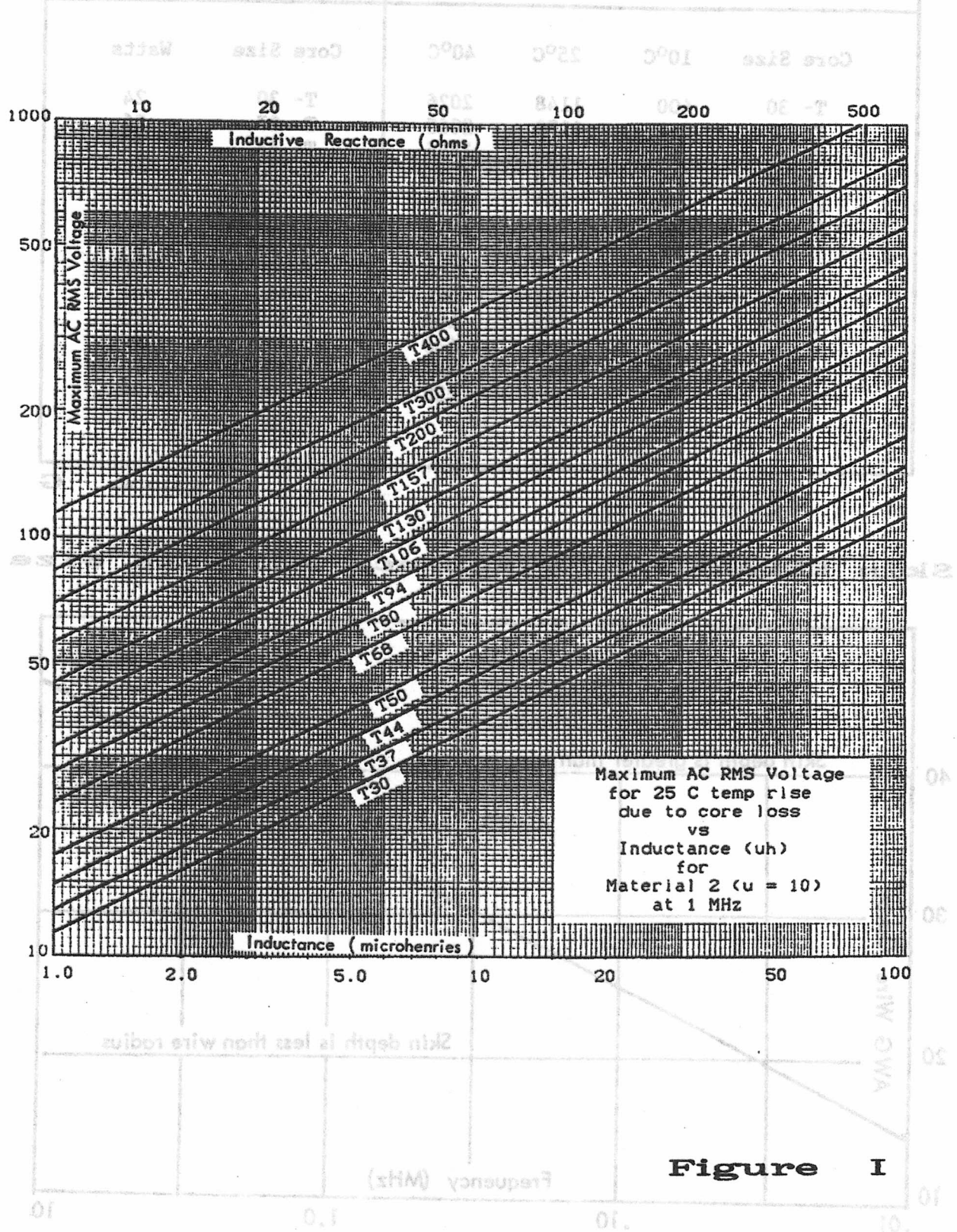


Figure I

AC RMS Current For 25 degree temperature rise at 1 MHz.

Iron Powder #2 Material Permeability 10

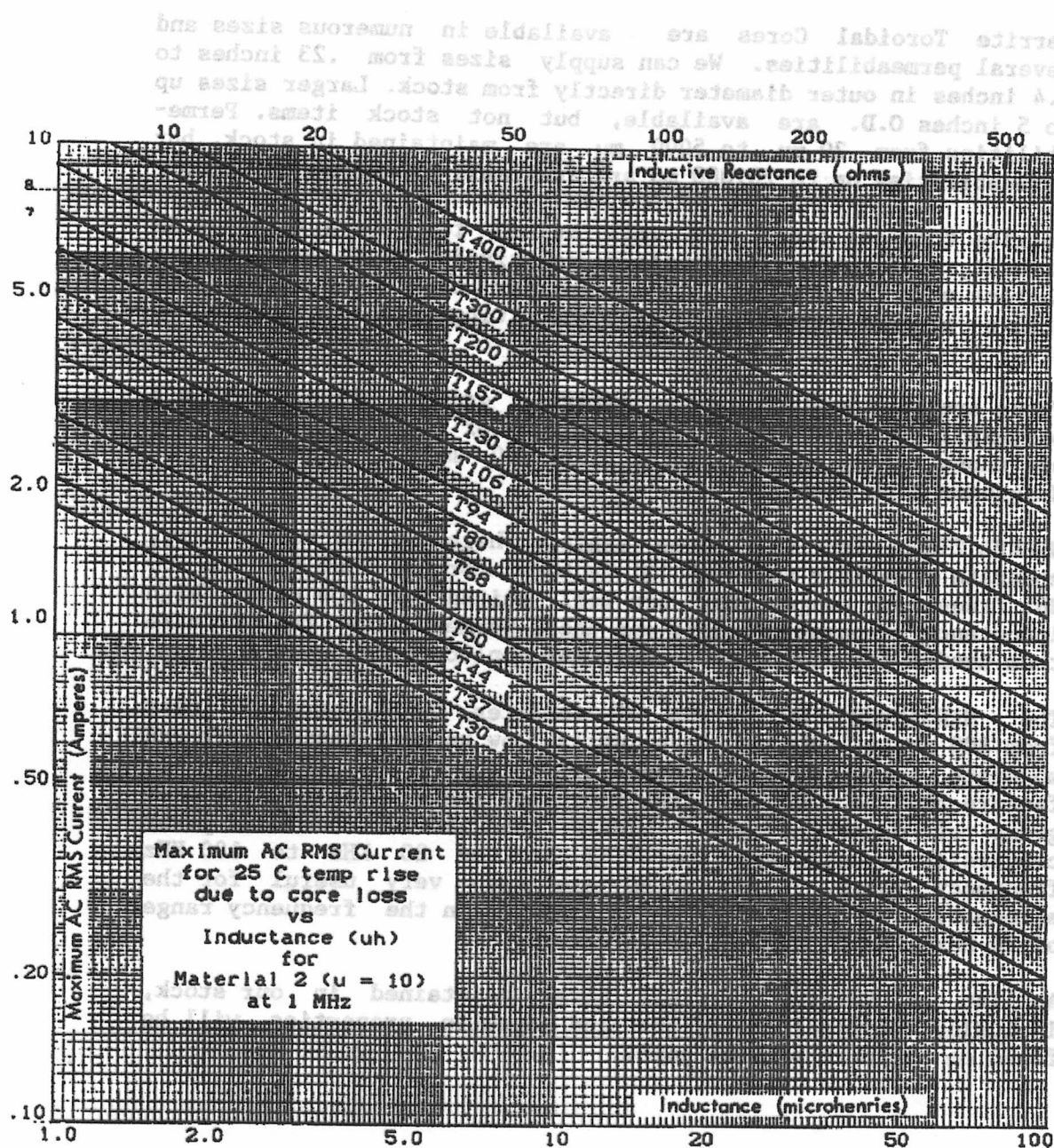


Figure J

Ferrite Toroidal Cores

Ferrite Toroidal Cores are available in numerous sizes and several permeabilities. We can supply sizes from .23 inches to 2.4 inches in outer diameter directly from stock. Larger sizes up to 5 inches O.D. are available, but not stock items. Permeabilities from 20 mu to 5000 mu. are maintained in stock, but permeabilities up to 20,000 mu are available as non-stock items.

Ferrite toroidal cores are well suited for a variety of RF circuit applications and their relatively high permeability factors make them especially useful for high inductance values with a minimum number of turns, resulting in smaller component size.

There are two basic ferrite material groups: those having a permeability range from 20 to 800 mu are of the NICKEL ZINC class and those having permeabilities above 800 mu are usually of the Manganese Zinc class.

NICKEL ZINC ferrite cores exhibit high volume resistivity, moderate stability and high 'Q' factors for the 500 KHz to 100 MHz frequency range. They are well suited for low power, high inductance resonant circuits and their permeability factors make them useful for wide band transformer applications.

The MANGANESE ZINC group of ferrites, having permeabilities from 800 mu to 5000 mu have fairly low volume resistivity and moderate saturation flux density. They can offer high 'Q' factors for the 1 KHz to 1 MHz frequency range. Cores from this group of materials are widely used for switched mode power conversion transformers operating in the 20 KHz to 100 KHz frequency range. These cores are also very useful for the attenuation of unwanted RF noise signals in the frequency range of 20 MHz. to 400 MHz and above.

A list of Ferrite toroidal cores maintained in our stock, including physical dimensions and magnetic properties, will be found on the next several pages.

Turns formula

$$\text{Turns} = 1000 \sqrt{\frac{\text{desired } L \text{ (mh)}}{A_L \text{ (mh/1000+)}}}$$

Key to part number

$$\frac{\text{FT}}{\text{ferrite toroid}} - \frac{50}{\text{OD}} - \frac{61}{\text{material}}$$

Ferrite Materials

Material 33 (permeability 850) A manganese-zinc material having low volume resistivity. Suitable for 1 KHz to 1 MHz. applications. Available in a variety of shapes and forms but most commonly used for antenna rods.

Material 43 (permeability 850) A nickel-zinc material having high volume resistivity. Widely used for medium frequency inductors and wideband trans-formers up to 50 MHz. Also very useful for frequency attenuation in the 30 MHz to 400 MHz range.

Material 61 (permeability 125) A nickel-zinc material which offers moderate temperature stability and high 'Q' for frequencies 0.2 MHz to 15 MHz. Also commonly used for wideband transformers up to 200 MHz.

Material 63 (permeability 40) A nickel-zinc ferrite having high volume resistivity and low permeability. A high 'Q' material for frequency range 15 MHz to 25 MHz. Extensively used in toroidal form. This material is going to be replaced with the superior #67 material.

Material 64 (permeability 250) A nickel-zinc material having high volume resistivity. Frequency range for resonant application up to 4 MHz. Good attenuation of unwanted frequencies up to 1000 MHz.

Material 67 (permeability 40) A nickel-zinc material very similar to the 63 material but having a greater saturation flux density. Somewhat lower volume resistivity but good temperature stability. Useful for high 'Q' applications 10 to 80 Mhz. and wideband transformers up to 200 MHz.

Material 68 (permeability 20) A nickel-zinc material having high volume resistivity and excellent temperature stability. Useful for high 'Q' resonant circuits 80 MHz. to 180 MHz. Widely used for high frequency inductors, antennas, wideband amplifiers, and linear power amplifiers.

Material 72 (permeability 2000) A manganese-zinc material having low volume resistivity. A high 'Q' material for the lower frequencies to 500 KHz. Also has excellent attenuation properties for unwanted frequencies from 500 KHz through 50 MHz. (Going to be replaced with the #77 material)

Material 73 (permeability 2500) A manganese-zinc material primarily a ferrite bead material having good attenuation properties for troublesome noise frequencies .5 MHz. through 50 MHz.

Material 75 and 'J' (perm 5000) A manganese-zinc material having low volume resistivity and low core loss from 1 KHz. to 1 MHz. Used for pulse transformers and low level wideband transformers. Also very useful for noise attenuation from .5 MHz to 20 MHz. frequency range.

Material 77 (permeability 2000) A manganese-zinc material having high saturation flux density at high temperature. Low core loss in the 1 KHz to 1 MHz range. Ideally suited for power conversion and wideband trans-formers. Also widely used for noise attenuation in the .5 Mhz. to 50 MHz. frequency range. (Will shortly be replacing the #72 material)

Material 'F' (permeability 3000) A manganese-zinc material similar to the 77 material but having somewhat greater initial permeability. High saturation flux density at high temperature. Used for power conversion transformers. Also used for noise attenuation in the .5 MHz. to 50 MHz. frequency range.

FERRITE TOROIDAL CORES

for resonant circuits

MATERIAL 43							Permeability 850
Core\ /number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_e cm ²	V_e cm ³	A_L value mh/1000 t
FT-23 -43	.230	.120	.060	1.34	.021	.029	188
FT-37 -43	.375	.187	.125	2.15	.076	.163	420
FT-50 -43	.500	.281	.188	3.02	.133	.401	523
FT-50A-43	.500	.312	.250	3.68	.152	.559	570
FT-50B-43	.500	.312	.500	3.18	.303	.964	1140
FT-82 -43	.825	.516	.250	5.26	.246	1.290	557
FT-114-43	1.142	.750	.295	7.42	.375	2.790	603
FT-140-43	1.400	.900	.500	9.02	.806	7.280	953
FT-240-43	2.400	1.40	.500	14.80	1.610	23.900	1239

MATERIAL 61							Permeability 125
Core\ /number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_e cm ²	V_e cm ³	A_L value mh/1000 t
FT-23 -61	.230	.120	.060	1.34	.021	.029	24.8
FT-37 -61	.375	.187	.125	2.15	.076	.163	55.3
FT-50 -61	.500	.281	.188	3.02	.133	.401	68.8
FT-50A -61	.500	.312	.250	3.68	.152	.559	75.0
FT-50B -61	.500	.312	.500	3.18	.303	.964	150.0
FT-82 -61	.825	.516	.250	5.26	.246	1.290	73.3
FT-114 -61	1.142	.750	.295	7.42	.375	2.790	79.3
FT-114A-61	1.142	.750	.545	7.42	.690	5.130	146.0
FT-140 -61	1.400	.900	.500	9.02	.806	7.280	140.0
FT-240 -61	2.400	1.40	.500	14.80	1.610	23.900	171.0

MATERIAL 63/67							Permeability 40
Core\ /number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_e cm ²	V_e cm ³	A_L value mh/1000 t
FT-23 -63/67	.230	.120	.060	1.34	.021	.029	7.9
FT-37 -63/67	.375	.187	.125	2.15	.076	.163	19.7
FT-50 -63/67	.500	.281	.188	3.02	.133	.401	22.0
FT-50A-63/67	.500	.312	.250	3.68	.152	.559	24.0
FT-50B-63/67	.500	.312	.500	3.18	.303	.964	48.0
FT-82 -63/67	.825	.516	.250	5.26	.246	1.290	22.4
FT-114-63/67	1.142	.750	.295	7.42	.375	2.790	25.4
FT-140- /67	1.400	.900	.500	9.02	.806	7.280	140.0
FT-240- /67	2.400	1.400	.500	14.80	1.610	23,900	171.0

MATERIAL 68							Permeability 20
Core\ /number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_e cm ²	V_e cm ³	A_L value mh/1000 t
FT-23 -68	.230	.120	.060	1.34	.021	.029	4.0
FT-37 -68	.375	.187	.125	2.15	.076	.163	8.8
FT-50 -68	.500	.281	.188	3.02	.133	.401	11.0
FT-50A-68	.500	.312	.250	3.68	.152	.559	12.0
FT-82 -68	.825	.516	.250	5.26	.246	1.290	11.7
FT-114-68	1.142	.750	.295	7.42	.375	2.790	12.7

FERRITE TOROIDAL CORES

for resonant circuits

MATERIAL 72/77

Core\number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_{e2} cm ²	V_{e3} cm ³	Permeability 2000 A_L value mh/1000 t
FT-23 -72/77	.230	.120	.060	1.34	.021	.029	396
FT-37 -72/77	.375	.187	.125	2.15	.076	.163	884
FT-50 -72/77	.500	.281	.188	3.02	.133	.401	1100
FT-50A-72/77	.500	.312	.250	3.68	.152	.559	1200
FT-50B-72/77	.500	.312	.500	3.18	.303	.964	2400
FT-82 -72/77	.825	.516	.250	5.26	.246	1.290	1170
FT-114-72/77	1.142	.750	.295	7.42	.375	2.790	1270
FT-114A - 77	1.142	.750	.545	7.42	.690	5.130	2340
FT-140-72/77	1.400	.900	.500	9.02	.806	7.280	2250
FT-240-72/77	2.400	1.400	.500	14.80	1.610	23.900	2740

MATERIAL 75

Core\number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_{e2} cm ²	V_{e3} cm ³	Permeability 5000 A_L value mh/1000 t
FT-23 -75	.230	.120	.060	1.34	.021	.029	995
FT-37 -75	.375	.187	.125	2.15	.076	.163	2220
FT-50 -75	.500	.281	.188	3.02	.133	.401	2740
FT-50A -75	.500	.312	.250	3.68	.152	.559	2990
FT-87 -75	.825	.516	.250	5.26	.246	1.290	2940
FT-87A -75	.870	.540	.312	5.42	.522	2.829	6040
FT-114 -75	1.142	.750	.295	7.42	.375	2.790	1270
FT-140 -75	1.400	.900	.500	9.02	.806	7.280	6736
FT-240 -75	2.400	1.400	.500	14.80	1.610	23.900	6845

MATERIAL F

Core\number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_{e2} cm ²	V_{e3} cm ³	Permeability 3000 A_L value mh/1000 t
FT-87A -F	.870	.540	.500	5.42	.522	2.830	3624
FT-114 -F	1.142	.748	.295	7.32	.369	2.701	1902
FT-150 -F	1.500	.750	.250	8.30	.581	4.822	2640
FT-150A-F	1.500	.750	.500	8.30	1.110	9.213	5020
FT-193 -F	1.932	1.252	.625	12.310	1.220	16.620	3640
FT-193A-F	1.932	1.252	.750	12.310	1.490	19.940	4460

MATERIAL J

Core\number	O.D. (in)	I.D. (in)	Hgt (in)	l_e cm	A_{e2} cm ²	V_{e3} cm ³	Permeability 5000 A_L value mh/1000 t
FT-87A -J	.870	.540	.500	5.42	.522	2.830	6040
FT-114 -J	1.142	.748	.295	7.32	.369	2.701	3170
FT-140 -J	1.400	.900	.500	9.02	.806	7.280	6736
FT-150 -J	1.500	.750	.250	8.30	.581	4.822	4400
FT-150A-J	1.500	.750	.500	8.30	1.110	9.213	8365
FT-193 -J	1.932	1.250	.525	12.31	1.220	16.620	6065
FT-240 -J	2.400	1.400	.500	14.80	1.610	23.900	6845

FERRITE TOROIDAL CORES

Physical Dimensions - Ferrite Toroids

core size	OD inches	ID inches	Hgt inches	Mean length cm	Cross Sect cm ²	Volume cm ³
FT-23	.230	.120	.060	1.34	.021	.028
FT-37	.375	.187	.125	2.15	.076	.163
FT-50	.500	.281	.188	3.02	.133	.402
FT-50 -A	.500	.312	.250	3.18	.152	.483
FT-50 -B	.500	.312	.500	3.18	.303	.963
FT-82	.825	.520	.250	5.26	.246	1.294
FT-87 -A	.870	.540	.500	5.42	.522	2.829
FT-114	1.142	.750	.295	7.42	.375	2.783
FT-114-A	1.142	.750	.545	7.42	.690	5.120
FT-140	1.400	.900	.500	9.02	.806	7.270
FT-150	1.500	.750	.250	8.30	.591	4.905
FT-150-A	1.500	.750	.500	8.30	1.110	9.213
FT-193	1.930	1.250	.625	12.30	1.190	14.637
FT-193-A	1.930	1.250	.750	12.31	1.460	17.958
FT-240	2.400	1.400	.500	14.40	1.570	22.608

A_L Values (mH / 1000 turns) - Ferrite Toroids

To complete the part number add the Mix number to the Core size number
The 63 & 72 materials are being superseded by the 67 & 77 materials respectively.

Material > core size	43 u=850	61 u=125	63 u=250	67 u=40	68 u=20	72 u=2M	75 u=5M	77 u=2M	F u=3M	J u=5M
FT-23	188	24.8	7.9	7.8	4.0	396	990	356	NA	NA
FT-37	420	55.3	17.7	17.7	8.8	884	2210	796	NA	NA
FT-50	523	68.0	22.0	22.0	11.0	1100	2750	990	NA	NA
FT-50 -A	570	75.0	24.0	24.0	12.0	1200	2990	1080	NA	NA
FT-50 -B	1140	150.0	48.0	48.0	12.0	2400	NA	2160	NA	NA
FT-82	557	73.3	22.4	22.4	11.7	1170	2930	1060	NA	NA
FT-87 -A	NA	NA	NA	NA	NA	NA	NA	NA	3624	6040
FT-114	603	79.3	25.4	25.4	12.7	1270	3170	1140	1902	3170
FT-114-A	NA	146.0	NA	NA	NA	2340	NA	NA	NA	NA
FT-140	952	140.0	45.0	45.0	NA	2250	NA	2340	NA	5736
FT-150	NA	NA	NA	NA	NA	NA	NA	NA	2640	4400
FT-150-A	NA	N	NA	NA	NA	NA	NA	NA	5020	8370
FT-193	NA	NA	NA	NA	NA	NA	NA	NA	3640	6065
FT-193-A	NA	NA	NA	NA	NA	NA	NA	NA	4460	NA
FT-240	1240	173.0	53.0	53.0	NA	3130	6845	3130	NA	6845

Magnetic Properties - Ferrite Materials

Material >	43	61	63	67	68	72	75	77	F	J
Initial Perm.	850	125	40	40	20	2000	5000	2000	3000	5000
Max Perm.	3000	450	125	125	40	3500	8000	6000	4300	9500
Max Flux den. 14 oer, gauss	2750	2350	1850	3000	2000	3500	3900	4600	4700	4300
Residual flux density, gauss	1200	1200	750	1000	1000	1500	1250	1150	900	500
Vol. Resist. ohms/cm	1x10 ⁵	1x10 ⁸	1x10 ⁸	1x10 ⁷	1x10 ⁷	1x10 ²	5x10 ²	1x10 ²	1x10 ²	1x10 ²
Temp. Co-eff. 20-70 deg. C	1%	.15%	.10%	.13%	.06%	.60%	.90%	.60%	.25%	.4%
Curie Temp. C	130	350	450	500	450	150	160	200	250	140
Resonant Cir. Freq. MHz	.01 to 1 MHz	.2 to 10 MHz	15 to 25 MHz	10 to 80 MHz	80 to 180 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz	.001- 1 MHz
Wideband Freq. MHz. *	1 to 50 MHz	10 to 200	25 to 200	50 to 500	200- 1000	.5 to 30 MHz	.2 to 15 MHz	.5 to 30 MHz	.5 to 30 MHz	1 to 15 MHz
Attenuation RF Noise, MHz	20- 600	200- 1000	500- 2000	350- 1500	1000- 5000	1 - 50	.5- 20	1 - 50	1 - 50	.5 - 20

* Based on low power, small core applications: Listed frequencies will be lower with high power.

Inductance-Turns Chart, Ferrite Toroids

Inductance in millihenries

core number	A_L mh/1000	10	20	30	40	50	60	70	80	90	100
MATERIAL #43											
FT-23-43	188	.018	.075	.169	.300	.470	.677	.921	1.20	1.52	1.88
FT-37-43	420	.042	.168	.378	.672	1.05	1.51	2.06	2.69	3.40	4.20
FT-50-43	523	.052	.209	.471	.836	1.30	1.88	2.56	3.35	4.24	5.23
FT-50A-43	570	.057	.228	.513	.912	1.43	2.05	2.79	3.65	4.62	5.70
FT-50B-43	1140	.011	.456	1.03	1.82	2.85	4.10	5.59	7.30	9.23	11.4
FT-82-43	557	.056	.224	.503	.894	1.40	2.01	2.74	3.58	4.53	5.59
FT-114-43	603	.060	.241	.543	.965	1.51	2.17	2.95	3.86	4.88	6.03
FT-140-43	952	.095	.380	.857	1.52	2.38	3.43	4.66	6.09	7.71	9.52
FT-240-43	1239	.123	.494	1.11	1.97	3.09	4.44	6.05	7.90	9.96	12.3
MATERIAL #61											
FT-23-61	24.8	.002	.010	.022	.040	.632	.089	.122	.159	.201	.248
FT-37-61	55.3	.006	.022	.050	.088	.138	.199	.271	.354	.448	.553
FT-50-61	68.8	.007	.028	.062	.110	.172	.248	.337	.440	.557	.688
FT-50A-61	75.0	.008	.030	.068	.120	.186	.270	.366	.480	.608	.750
FT-50B-61	150.0	.015	.060	.135	.240	.375	.540	.735	.960	1.22	1.50
FT-82-61	73.3	.007	.029	.066	.111	.183	.264	.359	.469	.594	.733
FT-114-61	79.3	.008	.032	.071	.127	.198	.285	.389	.508	.642	.793
FT-114A-61	146.0	.015	.058	.131	.233	.365	.526	.715	.934	1.18	1.46
FT-140-61	140.0	.014	.056	.126	.224	.350	.504	.686	.896	1.13	1.40
FT-240-61	171.0	.017	.068	.154	.274	.428	.616	.838	1.09	1.39	1.71
MATERIAL #67											
FT-23-67	7.9	----	.003	.007	.013	.020	.028	.038	.051	.064	.079
FT-37-67	19.7	.002	.008	.018	.032	.049	.071	.097	.126	.160	.197
FT-50-67	22.0	.002	.009	.020	.035	.055	.079	.108	.141	.178	.220
FT-50A-67	24.0	.002	.010	.022	.038	.060	.086	.112	.154	.194	.240
FT-50B-67	48.0	.005	.019	.043	.077	.120	.173	.235	.307	.389	.480
FT-82-67	22.4	.002	.009	.020	.036	.056	.081	.110	.143	.181	.224
FT-114-67	25.4	.003	.010	.023	.041	.064	.091	.124	.163	.206	.254
FT-140-67	45.0	.005	.018	.041	.072	.118	.113	.220	.288	.365	.450
FT-240-67	53.0	.005	.021	.048	.084	.133	.191	.260	.339	.430	.530
MATERIAL #68											
FT-23-68	4.0	----	.002	.004	.006	.010	.014	.020	.026	.032	.040
FT-37-68	8.8	----	.006	.008	.014	.022	.032	.043	.056	.071	.088
FT-50-68	11.0	.001	.004	.010	.018	.028	.040	.054	.070	.089	.110
FT-50A-68	12.0	.001	.005	.011	.019	.030	.043	.059	.077	.097	.120
FT-82-68	11.7	.001	.005	.011	.019	.029	.042	.057	.075	.095	.117
FT-114-68	12.7	.001	.005	.011	.020	.032	.046	.062	.081	.103	.127

Inductance-Turns Chart, Ferrite Toroids

Inductance in millihenries

core number	A_L mh/1000†	10	20	30	40	50	60	70	80	90	100
MATERIAL 72											
FT-23-72	396	.040	.158	.356	.634	.990	1.43	1.94	2.53	3.21	3.96
FT-37-72	884	.088	.354	.796	1.41	2.21	3.18	4.33	5.66	7.16	8.84
FT-50-72	1100	.110	.440	.990	1.76	2.75	3.96	5.39	7.04	8.91	11.0
FT-50A-72	1200	.120	.480	1.08	1.92	3.00	4.32	5.88	7.68	9.72	12.0
FT-50-B-72	2400	.240	.960	2.16	3.84	6.00	8.64	11.7	15.4	19.4	24.0
FT-82-72	1170	.117	.467	1.05	1.87	2.93	4.21	5.73	7.49	9.48	11.9
FT-114-72	1270	.127	.508	1.14	2.03	3.18	4.57	6.22	8.13	10.3	12.7
FT-140-72	2340	.234	.936	2.13	3.74	5.85	8.42	11.4	15.0	19.4	23.4
FT-240-72	2740	.274	1.10	2.47	4.38	6.85	9.86	13.4	17.5	22.2	27.4
MATERIAL 75											
FT-23-75	995	.096	.398	.896	1.59	2.49	3.58	4.88	6.37	8.06	9.95
FT-37-75	2220	.222	.888	2.00	3.55	5.55	7.99	10.9	14.2	18.0	22.2
FT-50-75	2740	.274	1.10	2.47	4.38	6.85	9.86	13.4	17.5	22.2	27.4
FT-50A-75	2990	.299	1.20	2.69	4.78	7.48	10.8	14.7	19.1	24.2	29.9
FT-82-75	2940	.294	1.18	2.65	4.70	7.35	10.6	14.4	18.8	23.8	29.4
FT-114-75	3170	.317	1.27	2.85	5.07	7.93	11.4	15.5	20.3	25.7	31.7
MATERIAL 'F'											
FT-87A-F	3624	.362	1.45	3.26	5.80	9.06	13.0	17.8	23.2	29.4	36.2
FT-114-F	1902	.140	.761	1.71	3.04	4.76	6.84	9.32	12.2	15.4	19.0
FT-150-F	2640	.264	1.06	2.38	4.22	6.60	9.50	12.9	16.9	21.4	26.4
FT-150A-F	5020	.502	2.00	4.52	8.03	12.6	18.1	24.6	32.1	40.7	50.2
FT-193-F	4460	.446	1.78	4.01	7.14	11.1	16.1	21.9	28.6	36.1	44.6
MATERIAL 'J'											
FT-87A-J	6040	.604	2.42	5.44	9.66	12.6	21.7	29.6	38.7	48.9	60.4
FT-114-J	3170	.317	1.27	2.85	5.07	7.93	11.4	15.5	20.3	25.7	31.7
FT-150-J	4400	.440	1.76	3.96	7.04	11.0	15.8	21.6	28.1	35.6	44.0
FT-150A-J	8365	.837	3.35	7.53	13.4	20.9	30.1	41.0	53.5	67.8	83.7
FT-193-J	6065	.607	2.43	5.46	9.70	15.2	21.8	29.7	38.8	49.1	60.7

The following equations are useful for calculating the number of turns, the inductance or the A_L value of any Ferrite toroidal core. Each core has been assigned its own A_L value which is found in the preceding Ferrite toroidal core charts.

$$N = 1000 \sqrt{\frac{\text{desired 'L' (mh)}}{A_L \text{ (mh/1000 turns)}}}$$

$$L \text{ (mh)} = \frac{A_L \times N^2}{1,000,000}$$

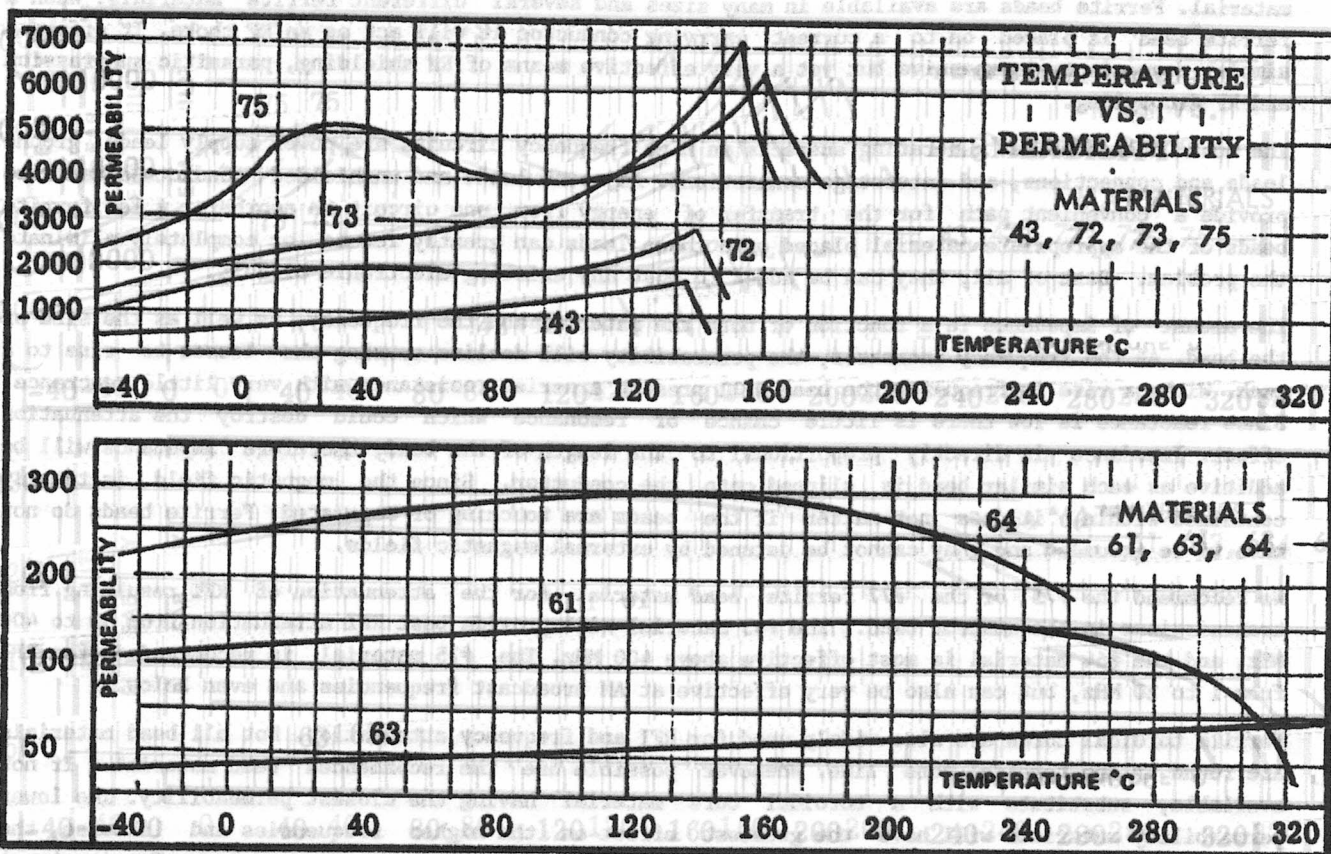
$$A_L \text{ (mh/1000 turns)} = \frac{1,000,000 \times 'L' \text{ (mh)}}{N^2}$$

N = number of turns

L = inductance (mh)

A_L = inductance index (mh / 1000 turns)

Temperature Curves - Ferrite Materials



Ferrite core size vs. Wire turns

Avg wire	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40
Core\No.																
FT-23	0	0	0	0	2	4	7	11	15	21	28	37	48	62	79	101
FT-37	0	0	2	4	7	11	15	21	28	36	48	61	79	100	127	161
FT-50	2	4	7	10	14	19	26	34	45	58	75	95	121	154	194	245
FT-50 -A	3	5	8	13	19	22	30	39	51	66	84	106	135	171	216	273
FT-50 -B	3	5	8	13	19	22	30	39	51	65	84	106	135	171	216	273
FT-82	9	13	18	22	32	41	53	69	88	112	143	180	228	288	362	456
FT-87A	10	14	19	25	34	43	56	72	92	118	150	188	239	302	374	478
FT-114	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-114-A	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-140	20	27	36	42	60	77	97	125	158	201	255	318	403	507	636	801
FT-150	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-150-A	16	22	29	38	49	63	80	100	131	166	211	263	334	420	527	665
FT-193	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
FT-193-A	31	41	53	68	86	109	139	176	223	282	357	445	562	707	886	1115
FT-240	36	46	60	77	98	123	156	198	250	317	400	499	631	793	993	1250

Approximate number of turns for full single layer winding on Ferrite Toroids.

FERRITE BEADS

A Ferrite Bead is a dowel-like device which has a center hole and is composed of ferromagnetic material. Ferrite beads are available in many sizes and several different ferrite materials. When a ferrite bead is placed on to a current carrying conductor it will act as an RF choke. It offers a simple, convenient, inexpensive but yet a very effective means of RF shielding, parasitic suppression and RF decoupling.

The most common noise generating suspects in high frequency circuits are power supply leads, ground leads and connections, and interstage connections. Adjacent leads and unshielded conductors can also provide a convenient path for the transfer of energy from one circuit to another. A few ferrite beads of the appropriate material placed onto these leads can greatly reduce or completely eliminate the problem. Best of all, they can be added to most any existing electronic circuit.

The amount of impedance is a function of both the material and the frequency, as well as the size of the bead. As the frequency increases, the permeability will decline causing the losses to rise to a peak. With a rise in frequency the bead will present a series resistance with very little reactance. Since reactance is low there is little chance of resonance which could destroy the attenuation effect. Impedance is directly proportional to the length of the bead, therefore impedance will be additive as each similar bead is slipped onto the conductor. Since the magnetic field is totally contained within, it does not matter if the beads are touching or separated. Ferrite beads do not have to be grounded and they cannot be detuned by external magnetic fields.

We recommend the #73 or the #77 ferrite bead material for the attenuation of RFI resulting from transmissions in the amateur band. The #43 material will provide best RFI attenuation from 30 to 400 MHz, and the #64 material is most effective above 400 MHz. The #75 material is recommended for RFI from 1 to 20 MHz, but can also be very effective at AM broadcast frequencies and even below.

Ferrite toroidal cores are also widely used for RFI and frequency attenuation. Not all bead materials are found in the toroidal core line. Whenever possible use the recommended bead material. If not available, substitute with a toroidal core material having the closest permeability. The lower permeability materials will have the greatest effect on the higher frequencies and likewise, the higher permeability materials will have the greatest effect on the lower frequencies. Ferrite cores are usually much larger than ferrite beads and because of this they will accept many more wire turns. In many cases, where space will permit, this is an advantage since the impedance increases as to the number of turns squared.

The number of turns on a single hole Ferrite bead or a toroidal core is identified by the number of times the conductor passes through the center hole. To physically complete one turn it would be necessary to cause the wires to meet on the outside of the device, however the bead or core does not care about the termination of each end of the wire and considers each pass through the center hole as one turn. (This does not apply to multihole beads)

When winding a six-hole bead, the impedance depends upon the exact winding pattern. For instance, it can be wound clock-wise or counter clock-wise progressively from hole to hole, or criss-crossed from side to side, or each turn can be completed around the outside of the bead. Each type of winding will produce very different results. The impedance for the six-hole bead in our chart is based on current industry standard, which is two and one half turns, going from one side to the other.

Fairly high currents can be tolerated before saturation begins to occur. If saturation does occur, impedance will drop to a very low level causing the bead to be ineffective as an RF attenuator. Once the cause of saturation has been removed, the bead will return to normal with no ill effects.

Temperature rise above the Curie point will also cause the bead to become non-magnetic, rendering it useless as a noise attenuating device. As soon as the cause of the temperature rise has been corrected, and the bead has been allowed to cool, normal operation will be regained and no damage will result. Depending on the material, Curie temperature can run anywhere from 120°C to 500°C. See 'Magnetic Properties' chart for specifics.

The #73 and #75 materials, as well as other very high permeability materials are semi-conductive and care should be taken not to position the cores or beads in such a manner that they would be able to short uninsulated leads together, or to ground. Other lower permeability materials with higher resistivity are non-conductive and this precaution is not necessary.

Ferrite Shielding Beads

Part number	Bead type	Dimensions (inches)			A _L of Materials (mh/1000 t)					Impedance factor*
		OD	ID	Hgt	43	64	73	75	77	
FB(--)-101	1	.138	.051	.128	510	150	1500	3000	----	1.0
FB(--)-201	1	.076	.043	.150	360	110	1100	----	----	0.7
FB(--)-301	1	.138	.051	.236	1020	300	3000	----	----	2.0
FB(--)-801	1	.296	.094	.297	1300	390	3900	----	----	2.5
FB(64)-901	2	.250	.050	.417	----	1130	----	----	----	**
FB(--)-1801	1	.200	.062	.437	2000	----	5900	----	----	3.9
FB(--)-2401	1	.380	.197	.190	520	----	1530	----	----	1.1
FB(--)-5111	3	.236	.032	.394	3540	1010	----	----	----	***
FB(--)-5621	1	.562	.250	1.125	3800	----	----	----	9600	7.4
FB(--)-6301	1	.375	.194	.410	1100	----	----	----	2600	2.1
FB(43)-1020	1	1.000	.500	1.112	3200	----	----	----	----	6.2
FB(77)-1024	1	1.000	.500	.825	----	----	----	----	5600	3.7
2X(43)-151	4	1.020	.500	1.125	Split bead type, material 43 only.					
2X(43)-251	4	.590	.250	1.125	Split bead type, material 43 only.					

Notes: Complete the part number by adding material number in (--) space provided.

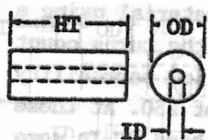
A_L values based on low frequency measurements.

(mh/1000 turns) equal to nanohenries/turns²

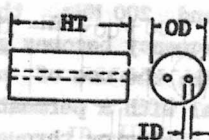
** Based on a single 'U-turn' winding.

*** Based on a 2 1/2 turn, side to side winding.

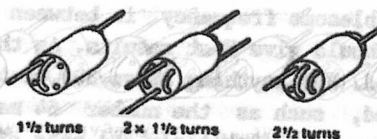
Type 1



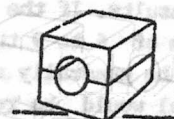
Type 2



Type 3

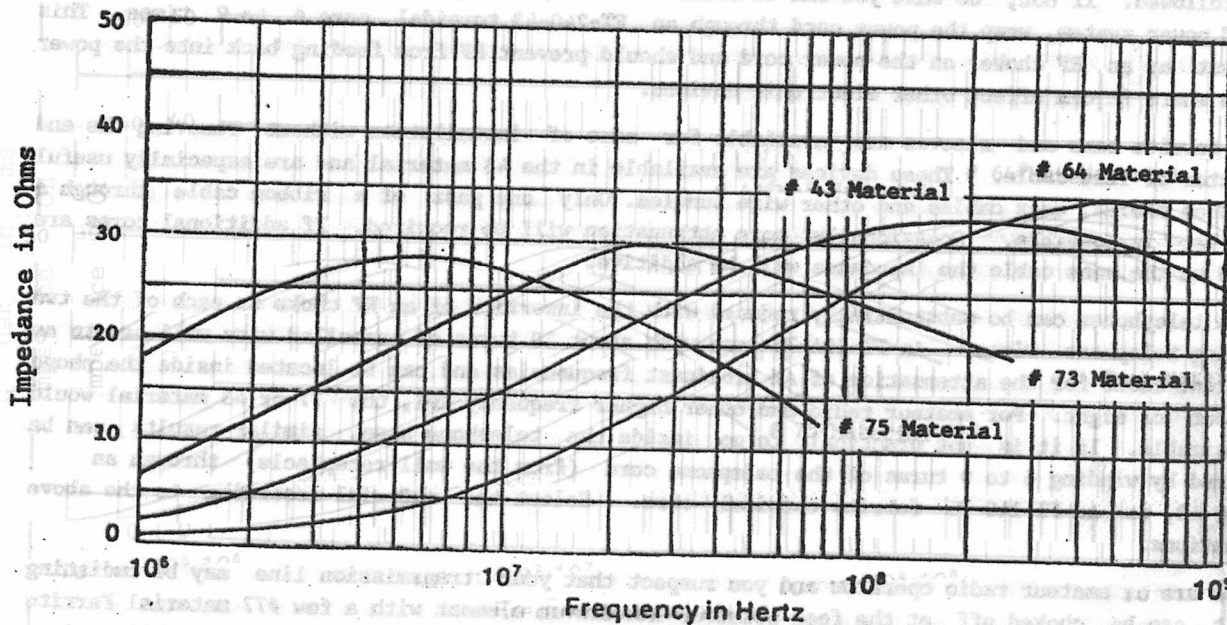


Type 4



Material vs Frequency vs Impedance

* Impedance Factor: The following chart is based on the '101' size bead which will be used as a reference. Impedance in ohms for a given size bead can be approximated, if the impedance of the '101' size bead (from the curves) is multiplied by the impedance factor for the given bead.



Using Ferrites for RFI Problems

Ferrite toroidal cores, ferrite beads and ferrite split cores can be very useful in the suppression of unwanted RF signals but we do not claim them to be a 'cure all' for all RFI problems. There are different types of noise sources, each of which may require a different approach. When dealing with any noise problem it is helpful to know the frequency of the interference. This is valuable in trying to determine the correct material to use as well as a guide line for maximum turns count.

When dealing with noise problems emanating from sources such as computers, flashing signs, switching devices, diathermy machines, etc. it is difficult to determine the exact frequency involved. We do know however, that devices of this nature are very rich in harmonics and can produce spikes in the high and very high frequency regions. For this type of interference, the #43 material is probably the best choice since it has very good attenuation characteristics from 30 to 400 MHz.

In some cases the geometry of the selected ferrite bead, core, or split bar, will allow only one pass of the conductor, which is considered to be one turn. In other cases it may be possible to wind several turns on to the core. When installing additional cores, or beads, on the same conductor, impedance will be additive. When multiple turns are wound on a core, impedance will increase in relation to the number of turns squared.

As a very general rule of thumb, we suggest the following. Bear in mind that because of the wide overlap in frequency range of the various materials, more than one material can provide acceptable results. For the 2 to 30 MHz range we suggest the 73, or 77 material with a maximum of 15 turns. For frequencies below 5 or 10 MHz, the 75 or 'J' material with a maximum of 30 turns will provide best results. If the troublesome frequency is between 30 and 200 MHz, the 43 material using a maximum of 6 to 9 turns should give best results. As the frequency becomes greater the turns count should be gradually reduced. For anything above 300 or 400 MHz, the use of a very low permeability material would be required, such as the number 64 material with a permeability of 250. At these frequencies, normal practice is to make only one pass of the conductor through the bead. In some cases it may require more than one bead.

Computers are notorious for RF radiation, especially some of the older models which were made when RFI requirements were very lax. RFI can radiate from inter-connecting cables, AC power cords and even from the cabinet itself. Needless to say, all sources must be free from radiation for an acceptable result.

First, examine the computer cabinet to make sure that good shielding and grounding practices have been followed. If not, do what you can to correct it. If you suspect that RF is feeding back into the AC power system, wrap the power cord through an FT-240-43 toroidal core 6 to 9 times. This will act as an RF choke on the power cord and should prevent RF from feeding back into the power system where it can affect other electronic devices.

Split ferrite bars and sleeves are available for ease of installation without removing the end connector of the cable. These devices are available in the 43 material and are especially useful on ribbon cables, coax cables and other wire bundles. Only one pass of a ribbon cable through a split bar is possible. Occasionally more attenuation will be required. If additional cores are placed on the same cable the impedance will be additive.

RFI in telephones can be substantially reduced with the insertion of an RF choke in each of the two incoming telephone wires. An FT-50A-75 core with about 20 turns of enamelled wire will create an excellent choke for the attenuation of AM broadcast frequencies and can be located inside the phone base out of sight. For amateur radio and other higher frequency RFI, the 77 or 43 material would be desirable. If it is not practical to go inside the telephone base, similar results can be obtained by winding 6 to 9 turns of the telephone cord (from the wall receptacle) through an FT-140-43, or an FT-140-75 ferrite toroidal core. Select the material according to the above suggestions.

If you are an amateur radio operator and you suspect that your transmission line may be radiating RF, it can be choked off at the feed point of the driven element with a few #77 material Ferrite Beads with an ID large enough to slip over the coax. This will prevent RF from travelling along the outside of the coax shield, which could be causing RFI in nearby electronic devices.

FERRITE CORES FOR RFI SUPPRESSION

Following is a list of large size Ferrite Beads (FB), Ferrite Toroidal Cores (FT), and Split Ferrite Cores (2X), all of which are extensively used for RFI problems involving multiple wire bundles, coaxial cables, microphone cables, AC cords, and computer ribbon cables. These larger ferrite beads and toroidal cores can provide larger ID's to accommodate the larger diameter coaxes and wire bundles.

The 43 material is a good all around material for most RFI problems. However the lower frequencies from .5 to 10 MHz. can best be served with the 'J' or 75 material. The 77 material can provide excellent attenuation of RFI caused by amateur radio frequencies from 2 to 30 MHz. and the 43 material is best for everything above 30 MHz. However, it is still very effective across the entire amateur band but not quite as good as the 77 material. The 73 material is specifically a ferrite bead material having a permeability of 2500 and can provide RF attenuation very similar to the 77 core material.

When more impedance is needed (with any bead or core) use additional cores on the same conductor or a core with a large enough ID to accommodate multiple wire turns. When additional cores are added, the impedance will be additive, but when additional wire turns are added the impedance increases as to the number of turns squared.

Split beads and 'bars' are also now available so that they may be installed without removing the end connector from the cable. Split bars are especially designed for computer ribbon cables. They are presently available for 1.3", 2.0" and 2.5" computer ribbon cables. Two or more may be used on the same cable to increase the impedance.

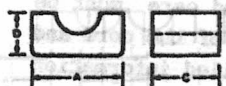
Shown below are typical impedances in ohms, 25 and 100 MHz with only one pass through the core.

Part number	A dim. (in)	B dim. (in)	C dim. (in)	25 MHz	100 MHz
FT-50B-43	.500	.312	.500	56	90
FT-50B-77	.500	.312	.500	74	60
FT-114-43	1.142	.750	.295	27	47
FT-114-77	1.142	.750	.295	35	29
FT-140-43	1.400	.900	.500	47	75
FT-140-77	1.400	.900	.500	62	50
FT-193- J	1.930	1.250	.625	below 10 MHz	
FT-240-43	2.400	1.400	.500	58	108
FT-240-77	2.400	1.400	.500	76	66

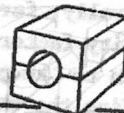


Two turns

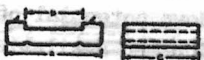
Note: All of the above size cores are available in the 'J' material which will be most effective if the troublesome frequency is below 10 MHz.



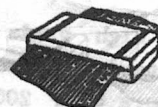
2X-43-251	.590	.250	1.125	171	275
2X-43-151	1.020	.500	1.125	159	245



FB-43-1020	1.000	.500	1.120	155	235
FB-77-1024	1.000	.500	.825	166	135
FB-43-5621	.562	.250	1.125	171	250
FB-77-5621	.562	.250	1.125	270	215
FB-43-6301	.275	.194	.410	55	48
FB-77-6301	.275	.194	.410	73	59



2X-43-651	for 1.3" ribbon cable	97	200
2X-43-951	for 2.0" ribbon cable	105	285
2X-43-051	for 2.5" ribbon cable	90	250

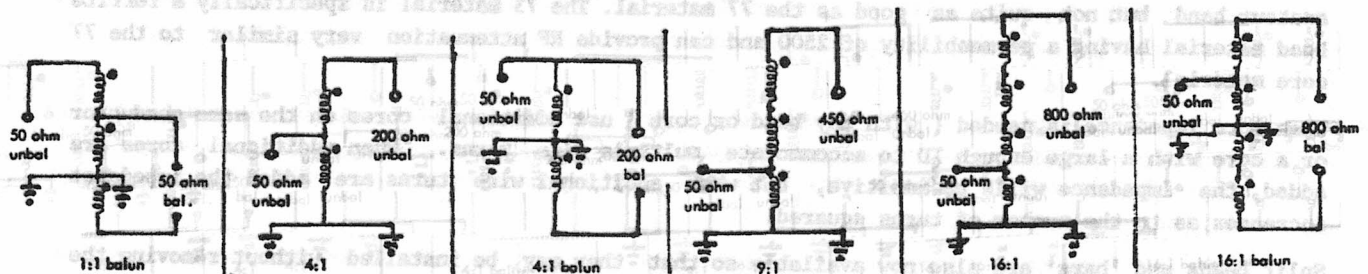


Broadband Transformers

Broadband Transformers, as the name implies, are transformers which will operate over a broad frequency range. They can also provide a step-up or a step-down impedance transformation, match an unbalanced source to a balanced load, or serve both purposes.

The two-hole, or 'binocular' type, ferrite core, known as the balun core, is very popular for low power applications. Balun cores were developed to provide maximum impedance per length of turn in order to better serve the broadband transformer. Two-hole balun cores are widely used as 75 ohm and 300 ohm (4:1 'Z' ratio, see below) matching transformers for receivers and low power UHF and VHF applications.

Below are shown a few popular winding configurations for baluns and impedance matching transformers. It is very important that the phasing dots be strictly adhered to for proper operation.



The bandwidth of a broadband transformer has practical limitations. The functions which control the low frequency performance are parallel inductance and parallel resistance. This combination must remain sufficiently high in order to maintain an acceptable match. Unless a very low 'Q' core is used these will be the dominant factors. Normally, the inductive reactance at the lowest frequency should be four times greater than the source impedance. However, in order to achieve this ratio, we may find that excessive turns may be required which will adversely affect the high frequency performance. Using a core of high permeability will minimize the number of required turns, however the possibility of saturation must be considered, especially in higher power applications. It is not uncommon to find one compromising the $4 \times X_L$ rule in order to obtain better high frequency performance.

The factors which limit the high frequency response are distributed capacity and inductance leakage due to uncoupled flux. The more the distributed capacity and the flux leakage can be minimized, the better will be the high frequency performance of the transformer. The best compromise between distributed capacity and leakage inductance can be obtained by twisting the conductors together prior to winding. This greatly minimizes the leakage inductance and at the same time the criss-cross effect of twisting the wires will help to cancel capacity build-up.

In applications which generate minimal flux, (low power and/or 1:1 'Z' ratio) the goals can best be accomplished by using a high permeability core in order to minimize turns at the lowest frequency. This in turn, will minimize distributed capacity which will improve the high frequency response.

Generally, ferrite type cores are preferred for broadband transformers because of their high permeability factors. However, high permeability ferrite cores can be easily saturated and care must be taken to keep the induced flux density well below the maximum flux density rating of the core and confine the the signal energy to the linear portion of the flux density curve. Detailed information can be found in 'Ferromagnetic Design and Applications Handbook' by Doug DeMaw and now available from Amidon.

The main concern in high power applications is core loss generated by the net induced flux. In this case, iron powder cores are generally preferred because of their higher maximum flux density rating. Core loss increases at a squared rate with flux density at any given frequency. When extremely high voltages are encountered, such as in a high impedance ratio step-up transformer, we recommend that the core first be wrapped with glass-electrical tape before winding, such as 3M-27. This will provide added protection against voltage breakdown and arcing.

A high grade of wire insulation is required when operating with high voltage. We recommend Thermoleze insulated wire. This is a very tough vinyl-like insulation having a voltage break-down potential of more than 2000 volts and a temperature rating of 180° C. This is a stock item at Amidon and available in sizes 10, 12, 14 and 16 AWG.

BALUN and WIDEBAND CORES

The two-hole balun is commonly used for winding high frequency wideband transformers. These transformers may be used for impedance transformation, to provide isolation, or both.

The primary concern when designing a wideband transformer is to extend the bandwidth with minimum loss. The factors which limit the bandwidth are inductive reactance and core loss which will limit operation at the lower frequencies, also leakage inductance and distributed capacitance which will limit operation at the higher frequencies.

The two-hole balun may be wound through both holes or through one hole and around the outside. Winding through both holes will produce a higher inductance per turn. Ferrite toroids and ferrite beads may also be used for winding wideband transformers, however these configurations will produce narrower bandwidth than the two-hole balun core.

For wideband application, the #73 material is suitable up to 30 MHz. The #43 material is most often used for frequencies from 20 to 50 or 60 MHz. For frequencies above this point use the #61 material.



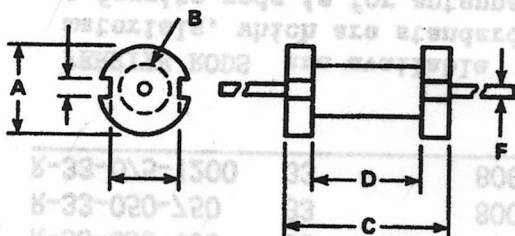
Dimensions in inches

A_L values in mh/1000 turns

	O.D	I.D	Hgt.	Th	type	A _L			O. D	I.D	Hgt	Th	type	A _L	
BN-43-202	.525	.150	.550	.295	1	2890			BN-61-2302	.136	.035	.240	.080	1	100
BN-43-2302	.136	.035	.240	.080	1	680			BN-61-2402	.280	.070	.240	.160	1	150
BN-43-2402	.280	.070	.240	.160	1	1275			BN-61-1702	.250	.050	.470	--	2	420
BN-43-3312	.765	.187	1.000	.375	1	5400			BN-61-1802	.250	.050	.240	--	2	310
BN-43-7051	1.130	.250	1.130	.560	1	6000			BN-73-202	.525	.150	.550	.295	1	8500
BN-61-202	.525	.150	.550	.295	1	425			BN-73-2402	.275	.070	.240	.160	1	3750

Ferrite Bobbin Cores

Ferrite bobbins provide a convenient means of winding RF chokes. Because of their open magnetic path, they can handle more current than toroids of similar size. To aid in the design of such chokes, we have provided A_L values, a winding table, and ampere-turn ratings for each bobbin.



Winding table: number of turns to completely fill bobbin.

wire size	20	22	24	26	28	30	32	34	36
B-72-1111	9	14	23	35	56	88	164	205	400
wire size	20	22	24	26	28	30	32	34	36
B-72-1011	24	39	60	93	148	230	425	535	1050

BOBBIN DIMENSIONS

A_L value in mh/1000 turns

part number	A	B	C	D	F	A_L	NI
Bobbin # B-72-1111	.196"	.107"	.500"	.400"	#22	17	60
Bobbin # B-72-1011	.372"	.187"	.750"	.500"	#20	39	130

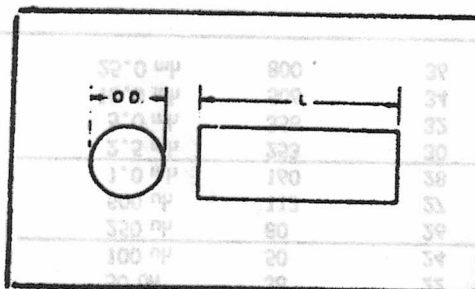
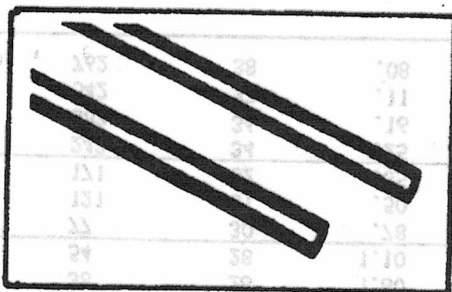
BOBBIN # B-72-1111 $A_L = 17$ NI = 60

Inductance	wire turns	wire size	I (max)
10 uh	24	24	2.50
25 uh	38	26	1.60
50 uh	54	28	1.10
100 uh	77	30	.78
250 uh	121	31	.50
500 uh	171	32	.35
1.0 mh	243	34	.25
2.5 mh	383	36	.16
5.0 mh	542	37	.11
10.0 mh	762	38	.08

BOBBIN # B-72-1011 $A_L = 39$ NI = 130

Inductance	wire turns	wire size	I (max)
25 uh	25	20	5.20
50 uh	36	22	3.60
100 uh	50	24	2.60
250 uh	80	26	1.60
500 uh	113	27	1.10
1.0 mh	160	28	.80
2.5 mh	253	30	.50
5.0 mh	358	32	.36
10.0 mh	506	34	.25
25.0 mh	800	36	.16

FERRITE RODS



Part number	Material	Permeability	Diameter (inches)	Length (inches)	A_L Value mH/1000†	Ampere turns
R-61-033-400	61	125	.33	4.0	32	210
R-61-050-400	61	125	.50	4.0	43	260
R-61-050-750	61	125	.50	7.5	49	575
R-33-037-400	33	800	.37	4.0	37	375
R-33-050-200	33	800	.50	2.0	51	465
R-33-050-400	33	800	.50	4.0	59	300
R-33-050-750	33	800	.50	7.5	70	200
R-33-075-1200	33	800	.75	12.0	98	330

FERRITE RODS are available in various different sizes of both the #33 and #61 materials, which are standard stock items here at Amidon. The most common use of a ferrite rods is for antennas and choke applications.

ANTENNAS: The #61 material rods are widely used for commercial AM radio antennas and on up to 10 MHz. The #33 material rods are more suitable for lower frequencies and the VLF range.

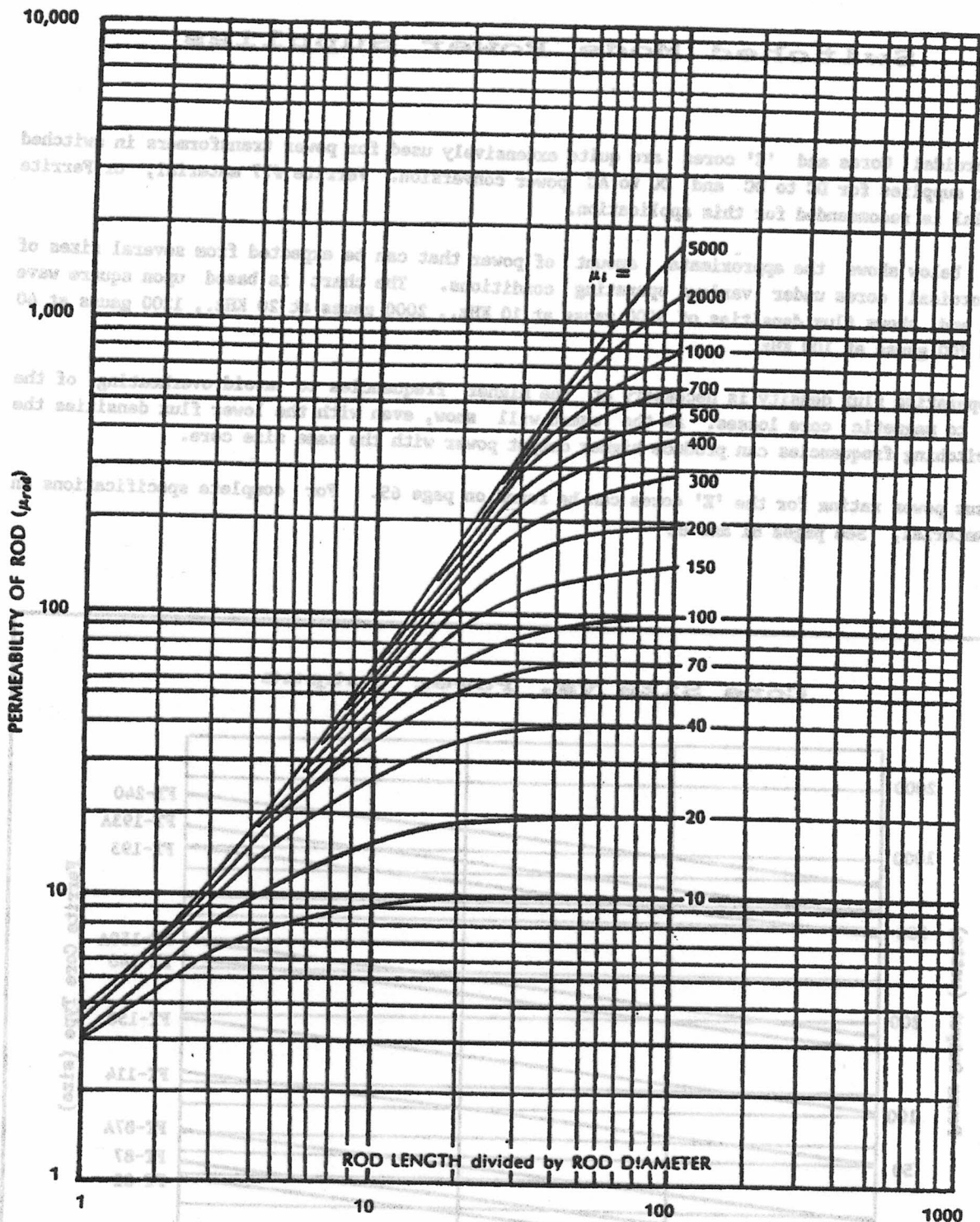
CHOKE APPLICATIONS; Both the #33 and the #61 material rods are extensively used in choke applications. The #33 material should be selected for the 40 and 80 meter bands and the #61 material is most suitable for 10 through 40 meters. The #33 material rods are quite often used in speaker cross-over networks. Due to the open magnetic structure of the rod configuration, considerable current can be tolerated before it will saturate.

There are several factors that have a direct bearing on the effective permeability of a ferrite rod, which in turn will effect inductance and 'Q', as well as the A_L value of the rod and its ampere-turns rating. These are: (1) Length to diameter ratio of the rod, (2) Placement of the coil on the rod, (3) Spacing between turns and, (4) Air space between the coil and the rod. In some cases the effective permeability of the rod will be influenced more by a change in the length to diameter ratio than by a change in the initial permeability of the rod. At other times, just the reverse will be true.

Greatest inductance and A_L value will be obtained when the winding is centered on the rod, rather than placed at either end. The best 'Q' will be obtained when the winding covers the entire length of the rod.

Because of all of the above various conditions it is very difficult to provide a workable set of A_L values, however we have attempted to provide A_L values only for comparison and to be used as a 'ballpark' starting point. These figures are based on a closely wound coil placed in the center of the rod. Please keep in mind that there can be a wide variation between calculated inductance and actual inductance, due to winding technique.

Permeability of Ferrite Rods



PERMEABILITY OF ROD vs. ROD LENGTH DIVIDED BY ROD DIAMETER FOR VARIOUS MATERIAL PERMEABILITIES

This family of curves shows the value of the effective permeability of a ferrite rod as a function of its length to diameter ratio, as well as a function of the material permeability of the rod. It illustrates that generally, a great difference exists between the material permeability and the effective permeability of a rod. It also illustrates how, in some instances, the effective permeability of a rod can be influenced by changing its mechanical dimensions, more than by changing its material permeability, while in other cases, the reverse is true.

Switched Mode Power Supplies

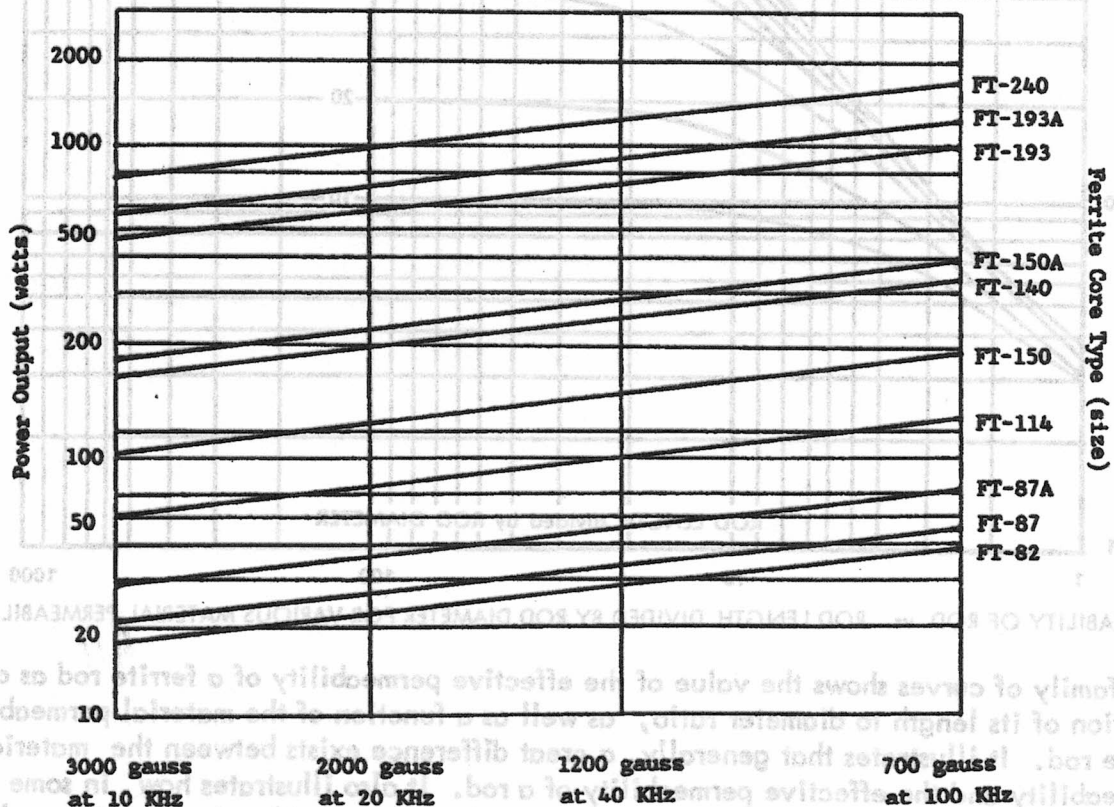
Ferrite Toroidal Cores and 'E' cores are quite extensively used for power transformers in switched mode power supplies for DC to DC and DC to AC power conversion. Ferrite #77 material, or Ferrite 'F' material is recommended for this application.

The chart below shows the approximate amount of power that can be expected from several sizes of Ferrite toroidal cores under various operating conditions. The chart is based upon square wave operation and shows flux densities of 3000 gauss at 10 KHz., 2000 gauss at 20 KHz., 1200 gauss at 40 KHz., and 700 gauss at 100 KHz.

A lower operating flux density is necessary at the higher frequencies to avoid overheating of the core due to magnetic core losses. As the chart will show, even with the lower flux densities the higher switching frequencies can produce higher output power with the same size core.

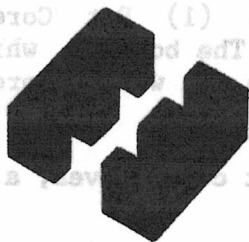
Size versus power rating for the 'E' cores can be found on page 65. For complete specifications on the #77 material, See pages 81 and 82

Core Size vs. Power Output



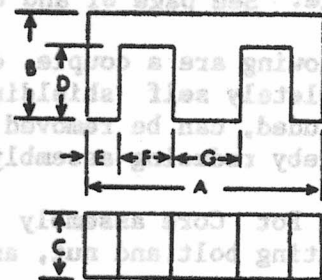
Switching Frequency and Flux Density

FERRITE 'E' CORES



TYPE 77 FERRITE MATERIAL permeability 2000

These cores are ideally suited for low power applications up to 200 watts. A nylon bobbin is supplied for easy winding.



E-Core Physical Dimensions (inches)

Part No. \\	A	B	C	D	E	F	G	Power
EA-77-188	.760	.318	.187	.225	.093	.192	.187	10 watts
EA-77-250	1.000	.380	.250	.255	.125	.250	.250	20 watts
EA-77-375	1.375	.562	.375	.375	.187	.312	.375	70 watts
EA-77-500	1.625	.650	.500	.405	.250	.312	.500	100 watts
EA-77-625	1.680	.825	.605	.593	.234	.375	.468	200 watts

E-Core Magnetic Properties

Part No. \\	A_e mm ²	I_e mm	V_e mm ³	A_s mm ²	A_w mm ²	$A_c \times A_w$ mm ⁴	A_L value mh/1000 turns
E-77-188	22.5	40.1	900	1050	55.7	1250	1290
E-77-250	40.4	48.0	1930	1700	80.6	3250	1520
E-77-375	90.3	68.8	6240	3630	151.0	13700	2540
E-77-500	160.0	76.7	12300	5410	163.0	26100	4090
E-77-625	184.0	98.0	18000	7550	287.0	52900	5210

Wire size vs. Number of turns

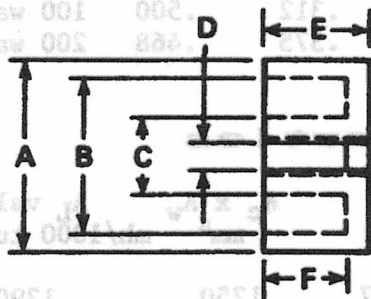
Part No. \\	18	20	22	24	26	28	30	32	34	36	38
EA-77-188	21	33	50	79	125	196	293	439	669	1046	1548
EA-77-250	34	62	93	147	232	364	532	814	1240	1938	---
EA-77-375	63	94	149	235	372	582	868	1302	1984	---	---
EA-77-500	50	141	212	335	532	829	1236	1855	---	---	---
EA-77-625	159	250	375	593	939	1470	2191	---	---	---	---

Ferrite Pot Cores

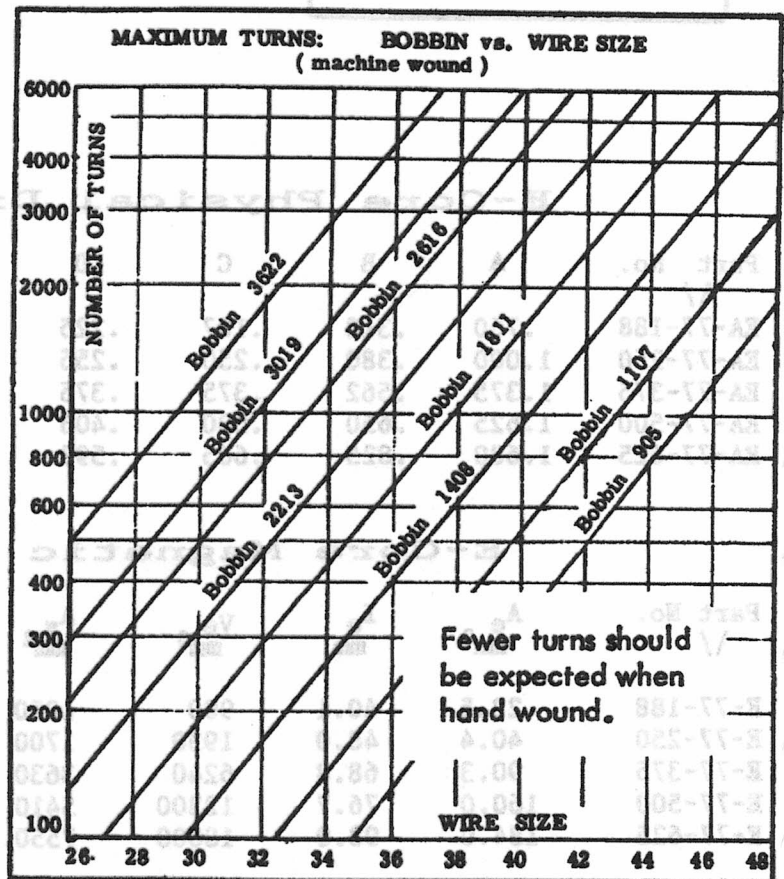
The Pot Cores listed below are manganese-zinc #77 ferrite material which have an initial permeability of 2000. This material has high saturation flux density and high temperature characteristics. Also, very low loss in the 1 KHz to 1 Mhz frequency range. See page 81 and 82 for complete specifications of the #77 material.

Following are a couple of advantages of using a pot core: (1) Pot Cores are completely self shielding against all adjacent RF fields. (2) The bobbin, which is included, can be removed from the pot core which will facilitate the winding process, thereby reducing assembly time to a minimum.

Each Pot Core assembly is supplied complete with the two pot core halves, a nylon mounting bolt and nut, and the nylon bobbin.



$$\text{Turns} = \sqrt{\frac{\text{desired } L \text{ (mh)}}{A_L \text{ (mh/1000}\dagger)}} \times 1000$$



Part number	Physical dimensions (mm)						Magnetic dimensions		
	A	B	C	D	E	F	l_e (mm)	A_e (mm) ²	A_L mh / 1000†
PC-1107-77	11.10	9.20	4.60	2.10	3.21	2.27	15.9	15.9	1420
PC-1408-77	14.05	11.80	5.90	3.10	4.18	2.90	20.0	25.0	1960
PC-1811-77	18.00	15.25	7.45	3.10	5.27	3.70	25.9	43.0	2880
PC-2213-77	21.60	18.70	9.25	4.55	6.70	4.70	31.6	63.0	3660
PC-2616-77	25.50	21.60	11.30	5.55	8.05	5.60	37.2	93.0	4700
PC-3019-77	30.00	25.40	13.30	5.55	9.40	6.60	45.0	136.0	5900
PC-3622-77	35.60	30.40	15.90	5.55	10.85	7.40	52.0	202.0	7680

l_e - Magnetic path length (mm)
 A_e - Cross sectional area (mm)²
 A_L - mh / 1000 turns

Core Loss vs. AC Flux Density

Ferrite #43 Material
Permeability 850

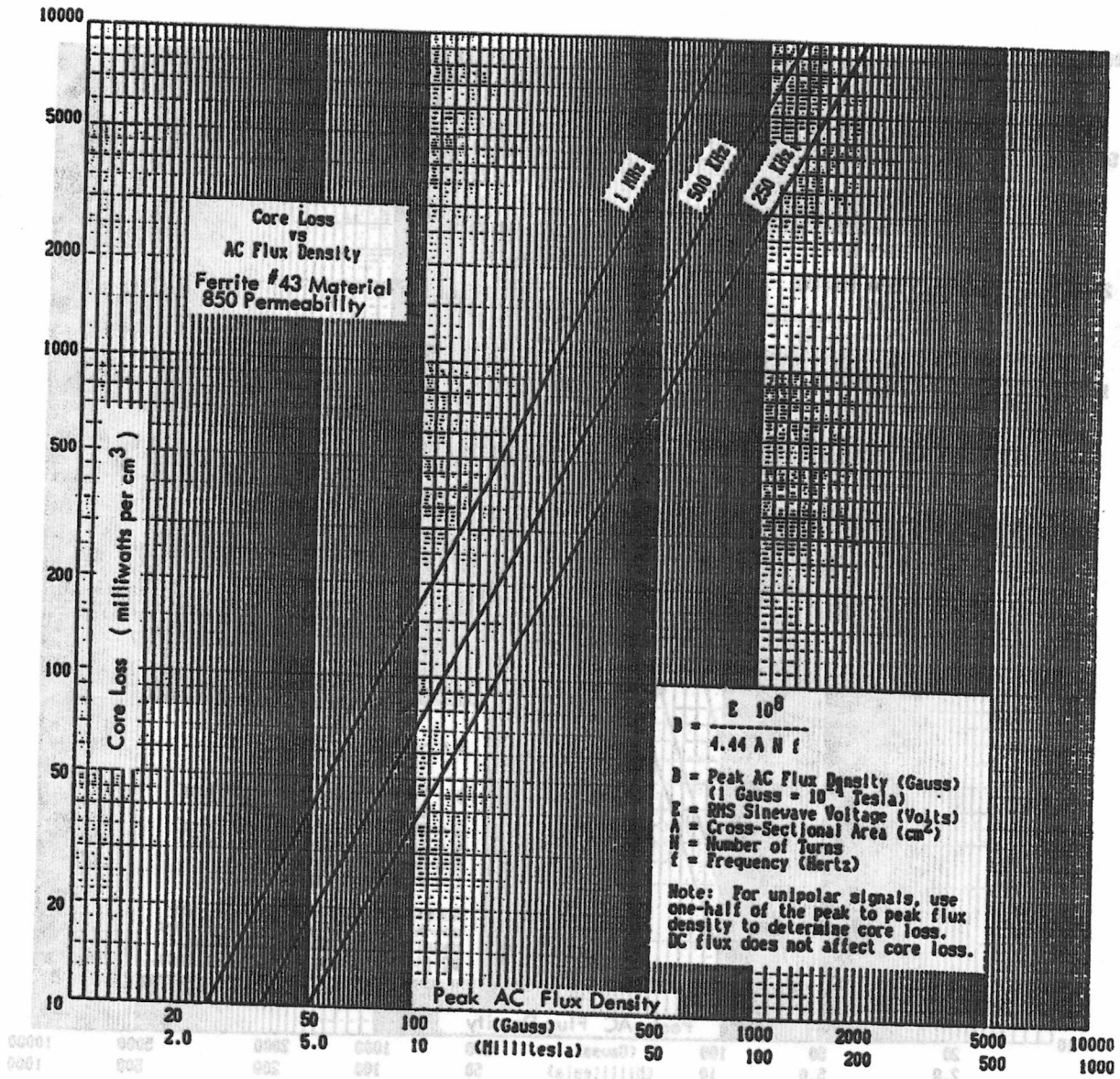


Figure 1

Core Loss vs. AC Flux Density

Ferrite #61 Material

Permeability 125

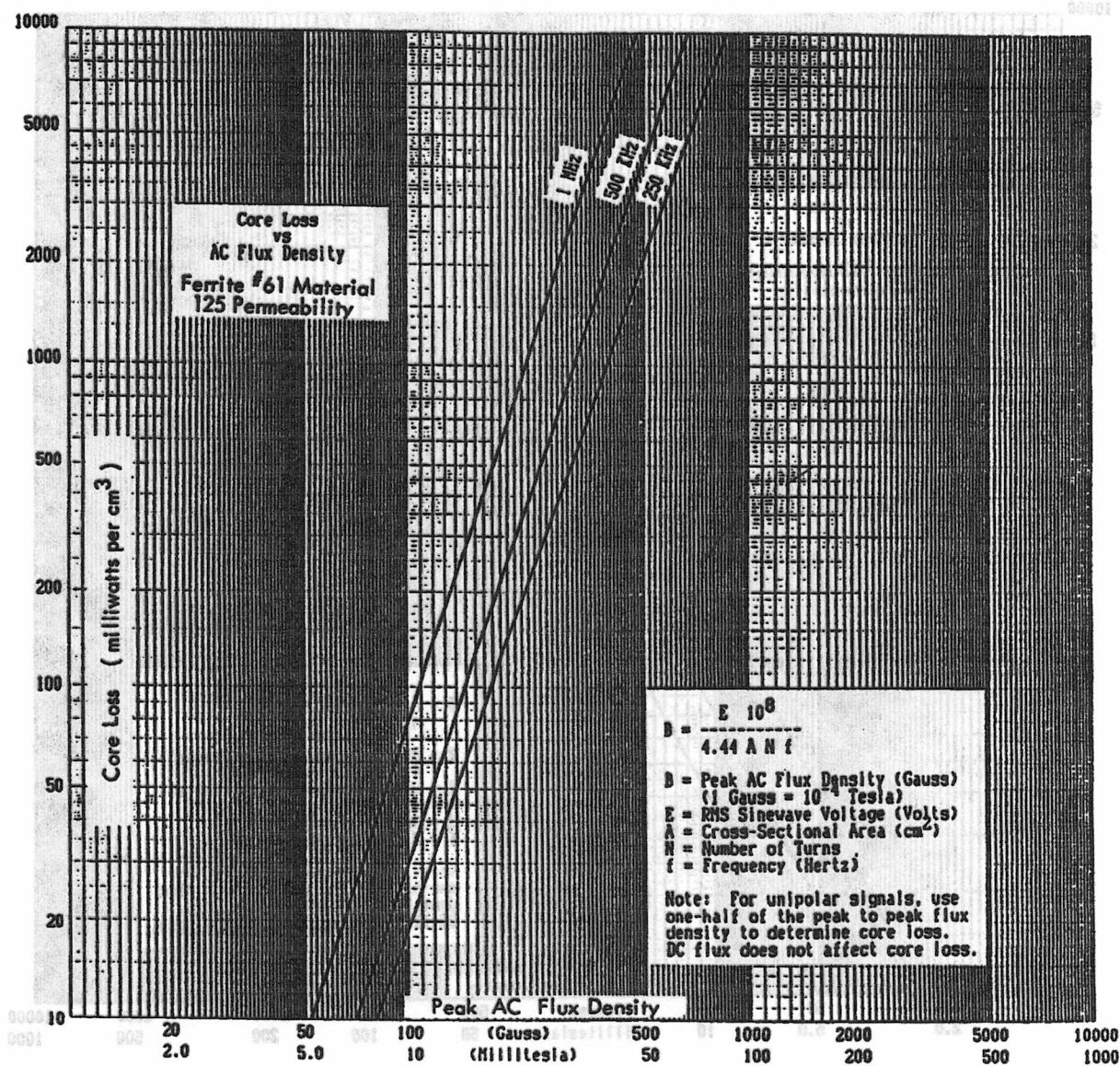


Figure 2

Core Loss vs. AC Flux Density

Ferrite #67 Material

Permeability 40

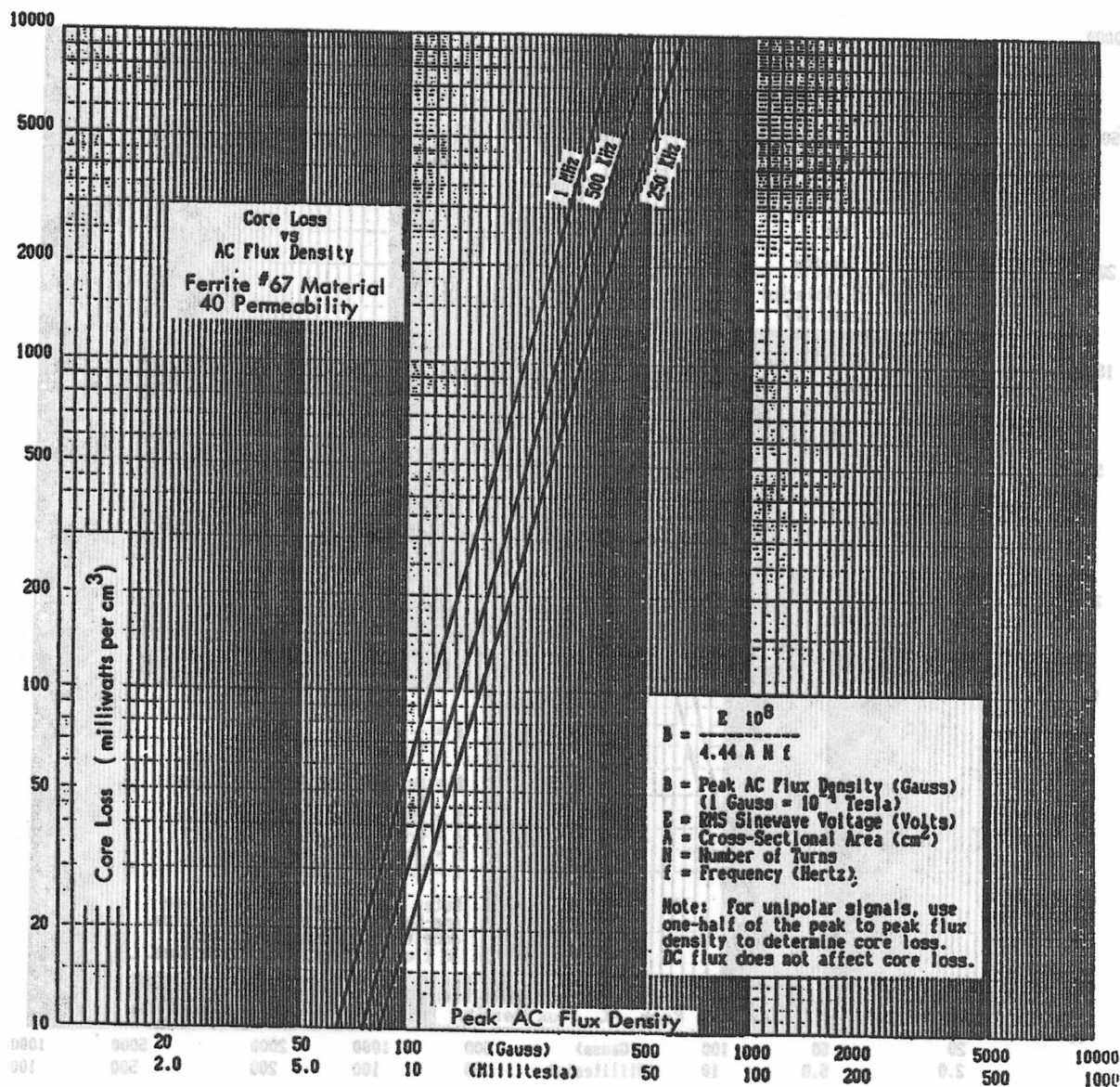


Figure 3

Core Loss vs. AC Flux Density

Ferrite #68 Material

Permeability 20

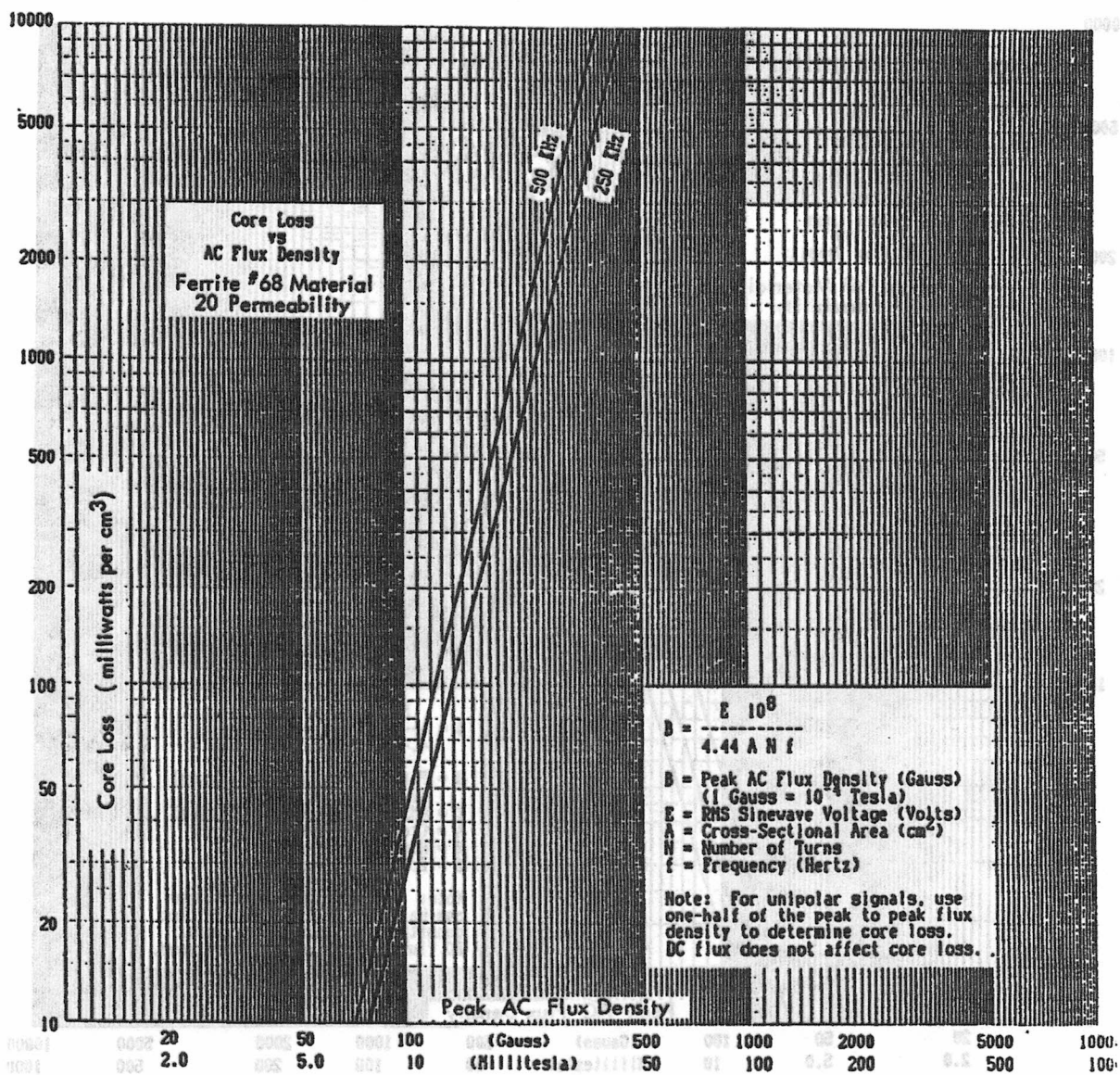


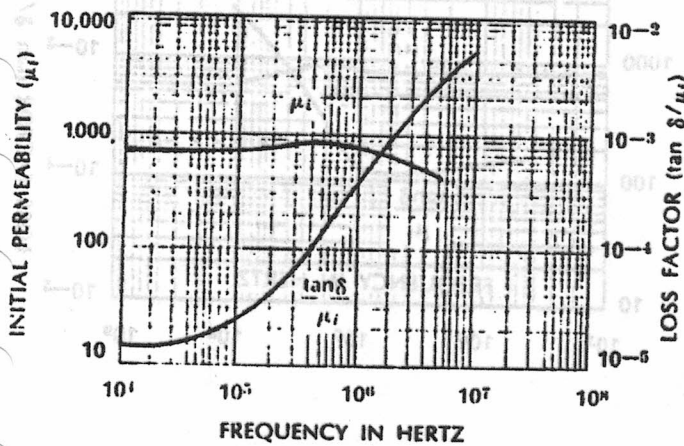
Figure 4

Ferrite Material 33

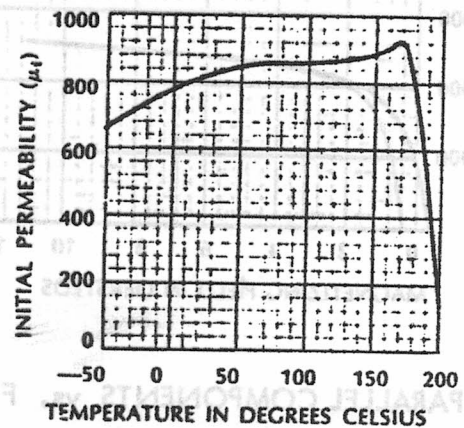
800 PERMEABILITY

33 MATERIAL (800 permeability) A MANGANESE-ZINC material having relatively low volume resistivity. Suitable for the 1 KHz to 1 MHz frequency range. Available in a variety of shapes and forms, but most commonly found in the antenna rod configuration for low and medium frequencies.

INITIAL PERM. & LOSS FACTOR vs. FREQ.

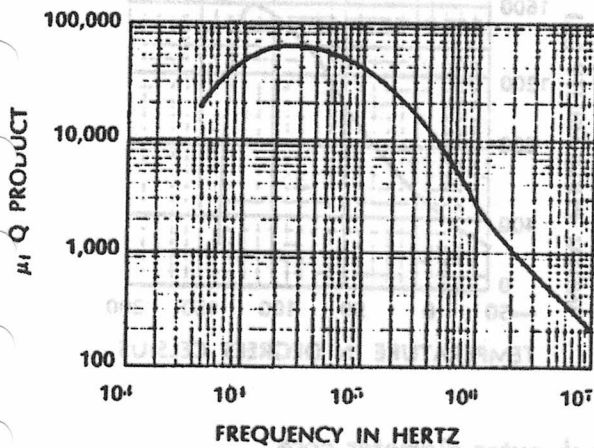


PERMEABILITY vs. TEMPERATURE

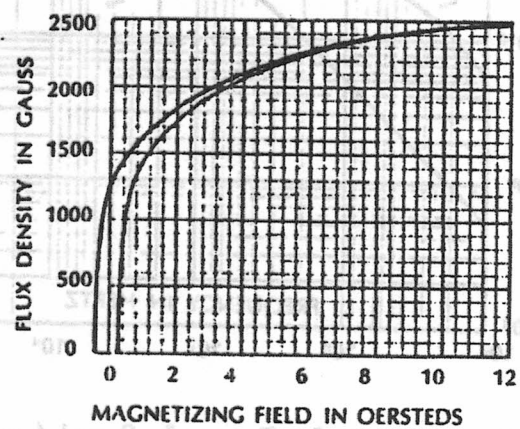


All measurements on a 1 inch outer diameter core.

'Q' vs. FREQUENCY



HYSTERESIS LOOP

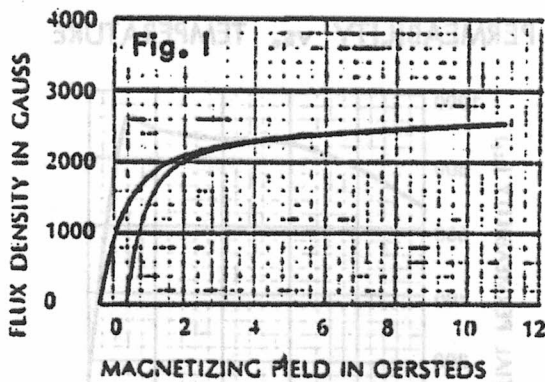


Ferrite Material 43

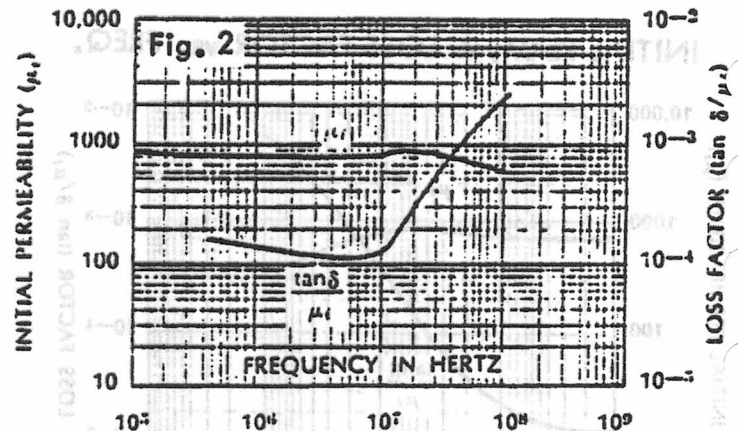
850 PERMEABILITY

#43 MATERIAL (850 permeability) A NICKEL-ZINC ferrite material having high volume resistivity. Widely used for medium frequency inductors in toroidal form and wide-band transformers up to 50 MHz. Extensively used in the shielding bead form for the suppression of unwanted RF signals from 50 MHz to 200 MHz.

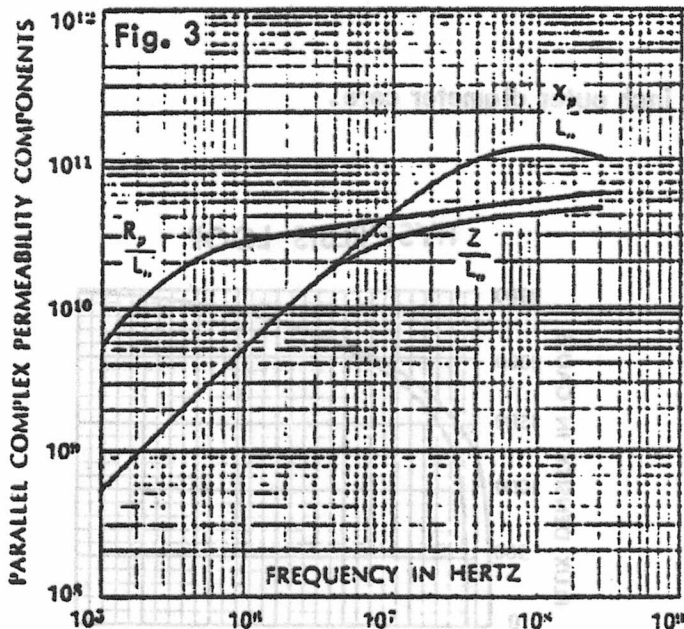
HYSTERESIS LOOP



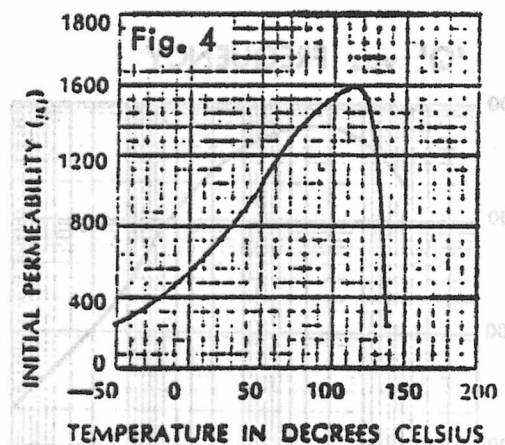
INITIAL PERM. & LOSS FACTOR vs FREQ.



PARALLEL COMPONENTS vs. FREQUENCY



INITIAL PERMEABILITY vs TEMPERATURE



Measurements for figures 1, 2 and 4 made with a 1 inch outer diameter core.
Figure 3 : Parallel resistance, reactance and impedance per air core inductance vs. frequency. Measurements made with a shielding bead. Data intended for use with wide-band amplifier applications.

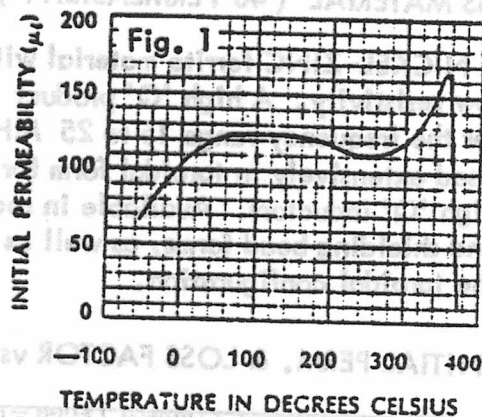
Ferrite Material 61

125 PERMEABILITY

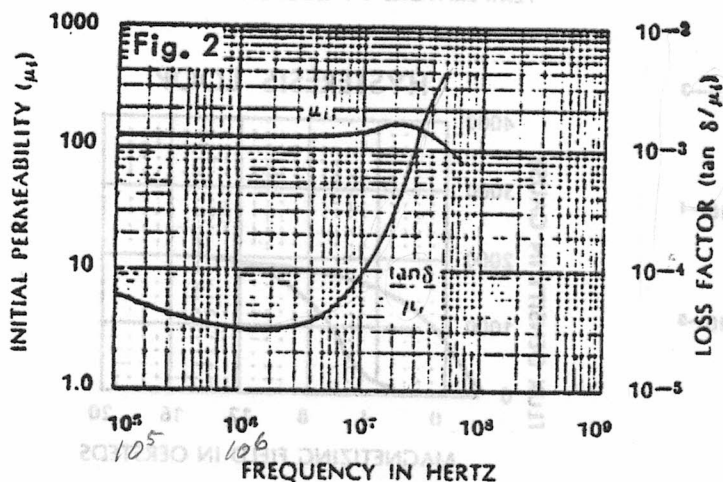
#61 MATERIAL (125 permeability)

A NICKEL-ZINC material which offers moderate temperature stability and high 'Q' for the 0.2 to 15 MHz frequency range. Primarily used in toroidal form for high 'Q' inductors. Also available in rod configuration and wide-band balun cores.

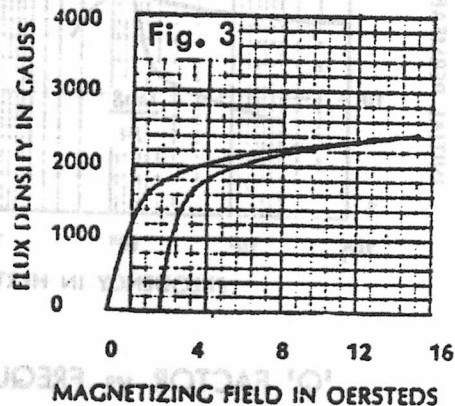
INITIAL PERMEABILITY vs TEMPERATURE



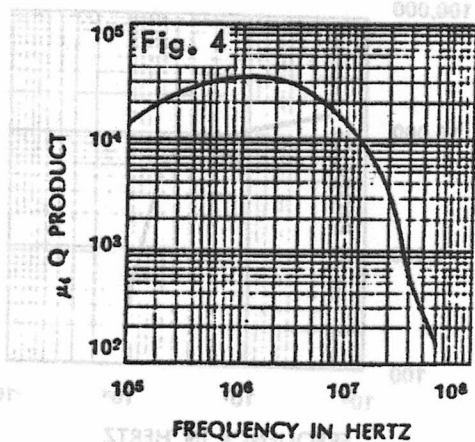
INITIAL PERM. & LOSS FACTOR vs FREQ.



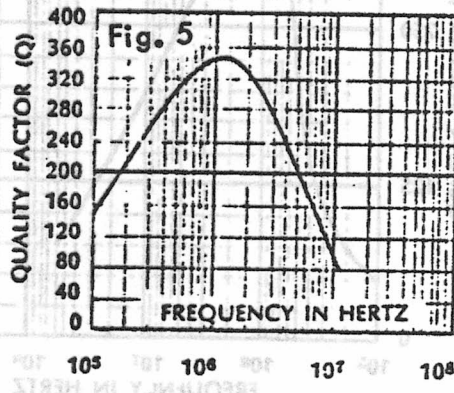
HYSTERESIS LOOP



'Q' PRODUCT ($\mu_i \times Q$) vs FREQUENCY



'Q' FACTOR vs FREQUENCY



Measurements for figures 1 and 3 made with a 1 inch outer diameter core.
Measurements for figures 2 and 5 were made with a .375 inch outer diameter core.

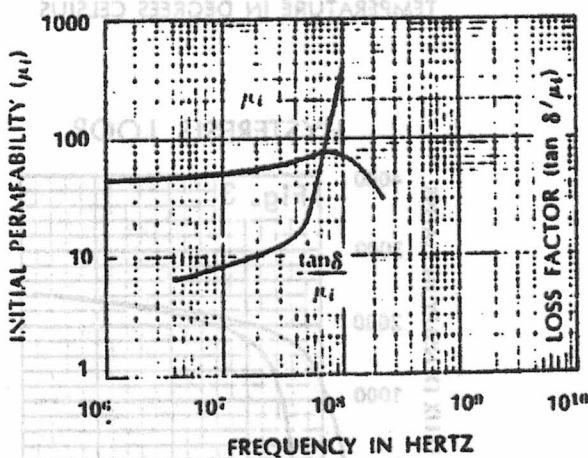
Ferrite Material 63

40 PERMEABILITY

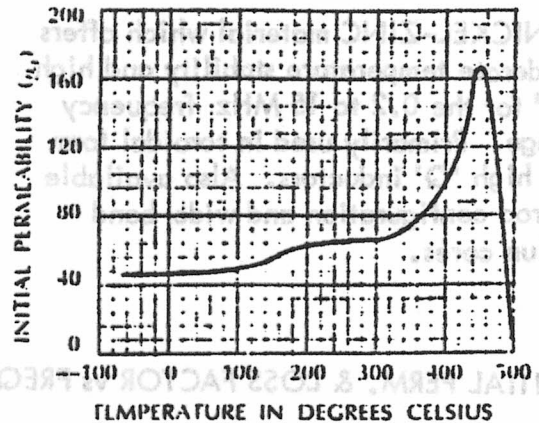
#63 MATERIAL (40 PERMEABILITY)

A NICKEL-ZINC ferrite material with low resistivity. A high 'Q' product for the frequency range 15 to 25 MHz. Used extensively in toroidal form for high 'Q' inductors. Available in rod and shielding bead forms, as well as the toroidal configuration.

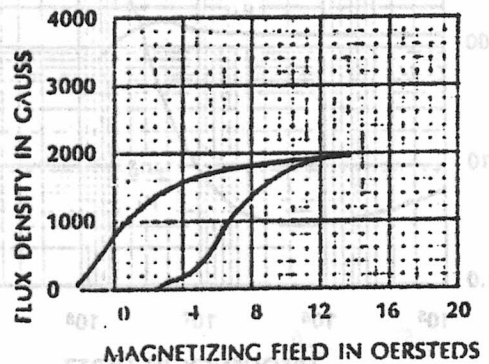
INITIAL PERM. & LOSS FACTOR vs FREQ.



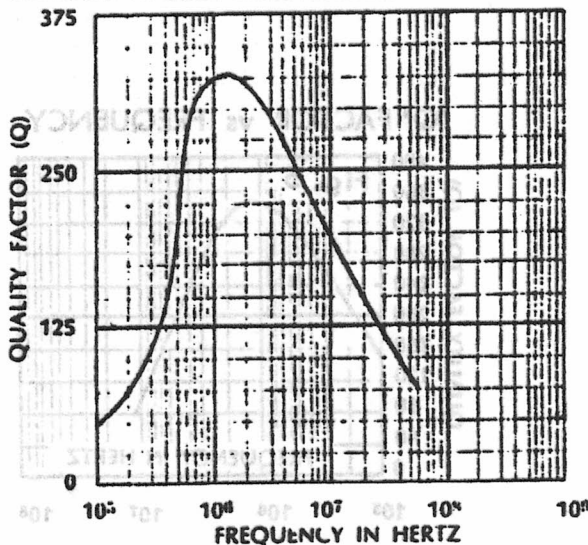
INITIAL PERMEABILITY vs TEMPERATURE



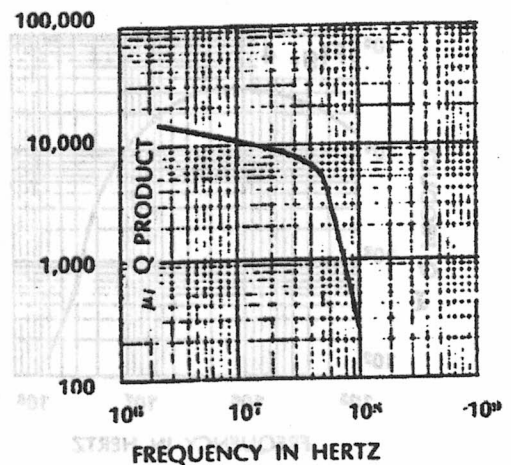
HYSTERESIS LOOP



'Q' FACTOR vs FREQUENCY



'Q' PRODUCT ($\mu_o \times Q$) vs FREQUENCY



All measurements made with a one inch outer diameter core.

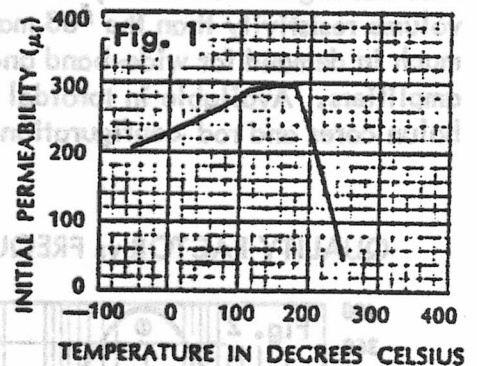
Ferrite Material 64

250 PERMEABILITY

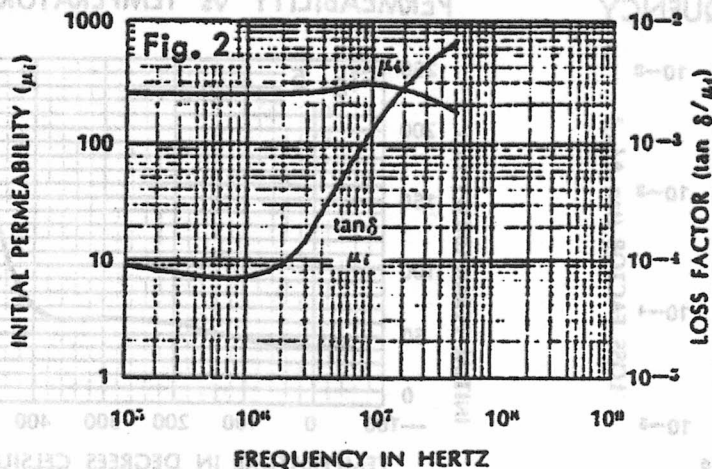
#64 MATERIAL (250 PERMEABILITY)

A NICKEL-ZINC ferrite material with high volume resistivity. Frequency range for resonant circuits up to 4 MHz. Has good shielding properties and is primarily used for shielding beads to attenuate unwanted RF frequencies above 200 MHz.

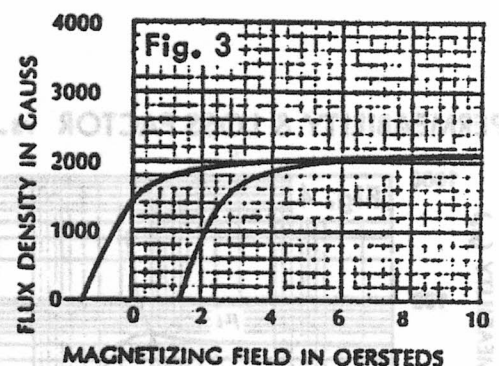
INITIAL PERMEABILITY vs TEMPERATURE



INITIAL PERM. & LOSS FACTOR vs FREQ.



HYSTERESIS LOOP



Measurements for figures 1 and 2 were made with a 1 inch outer diameter core.
Measurements for figure 3 were made with a one half inch outer diameter core.

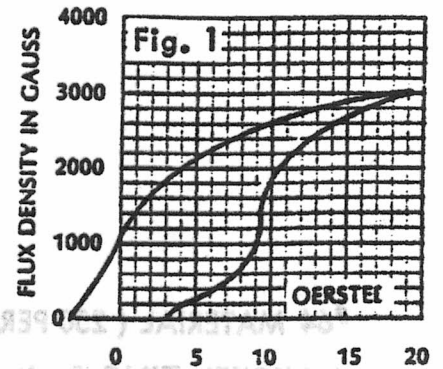
Ferrite Material 67

40 PERMEABILITY

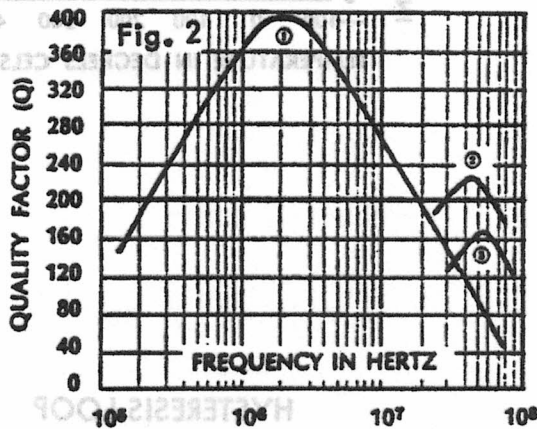
#67 MATERIAL (40 PERMEABILITY)

A NICKEL-ZINC ferrite material very similar to the #63 material, but with extended frequency range 10 to 80 MHz. Has excellent stability and very useful for high 'Q', high frequency circuits. Also has higher flux density and somewhat lower volume resistivity than the #63 material. Very much in demand for wide-band and linear power amplifiers. Available in toroidal form, wide-band balun cores and rod configuration.

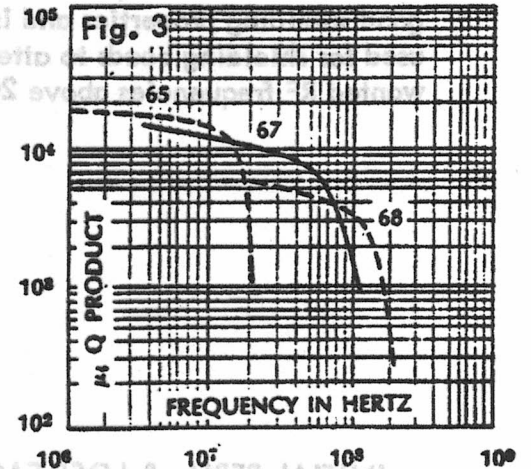
HYSTERESIS LOOP



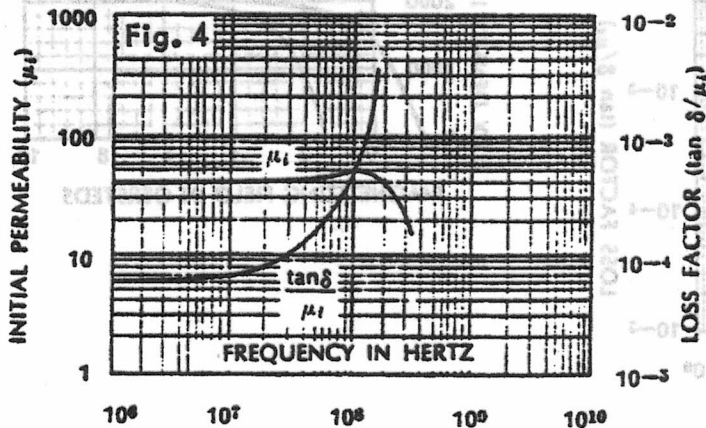
QUALITY FACTOR vs FREQUENCY



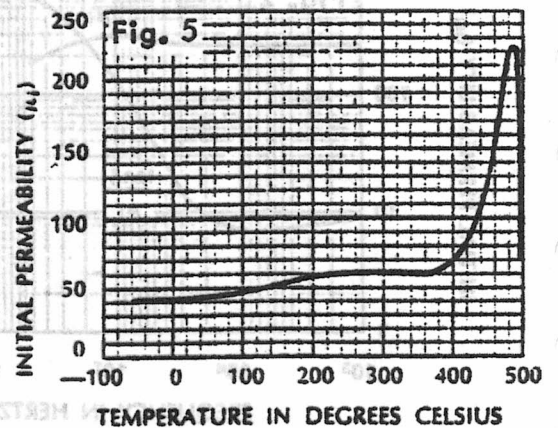
'Q' PRODUCT ($\mu_0 \times Q$) vs FREQUENCY



PERMEABILITY & LOSS FACTOR vs. FREQUENCY



PERMEABILITY vs TEMPERATURE



Measurements for figures 1 and 5 were made with a 1 inch outer diameter core.

Measurements for figures 2 and 4 were made with a .375 inch outer diameter core.

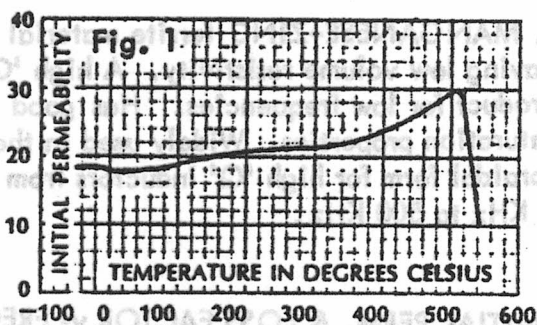
Ferrite Material 68

20 PERMEABILITY

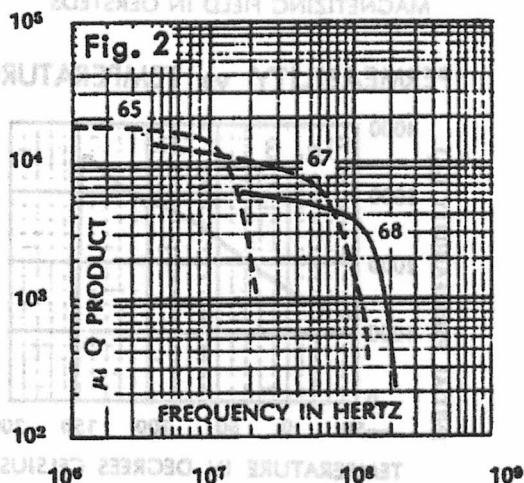
#68 MATERIAL (20 PERMEABILITY)

A NICKEL-ZINC ferrite material having high volume resistivity and excellent temperature stability. High 'Q' for the frequency range 80 to 180 MHz. Used for high frequency inductors, antennas, wide-band amplifiers and linear power amplifiers. Available in toroidal form, antenna rods and shielding beads.

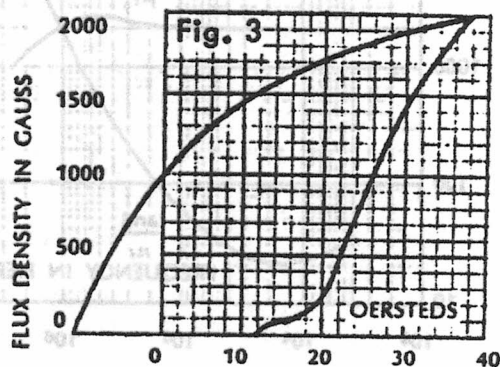
PERMEABILITY vs TEMPERATURE



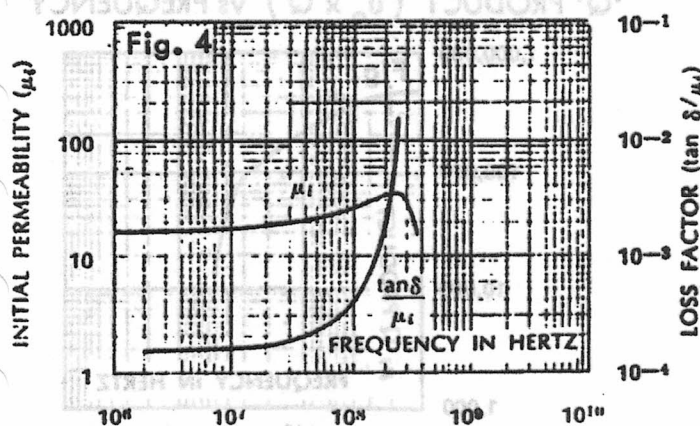
'Q' PRODUCT ($\mu_0 \times Q$) vs FREQUENCY



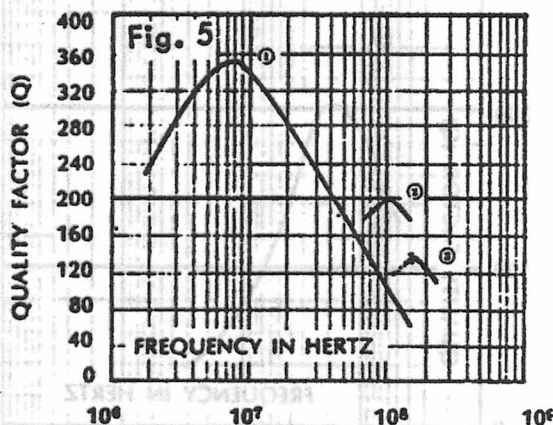
HYSTERESIS LOOP



PERMEABILITY & LOSS FACTOR vs FREQUENCY



QUALITY FACTOR 'Q' vs FREQUENCY



Measurements for figures 1 and 4 were made with a 1 inch outer diameter core
Measurements for figures 4 and 5 were made with a .375 inch outer diameter core.

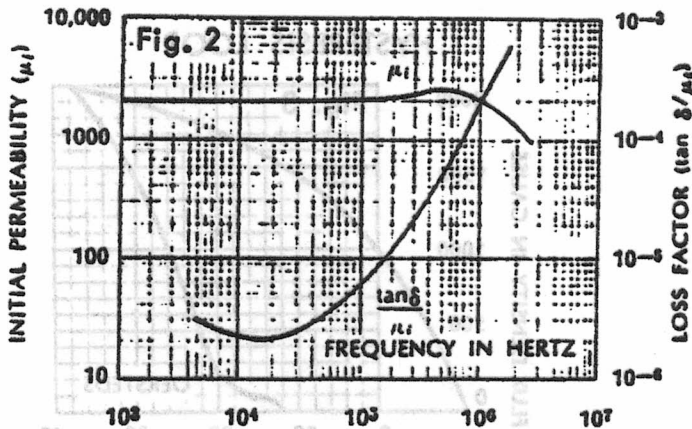
Ferrite Material 72

2000 PERMEABILITY

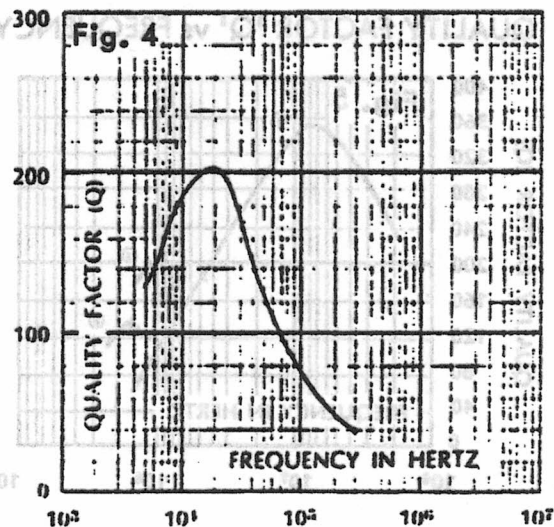
#72 MATERIAL (2000 PERMEABILITY)

A MANGANESE-ZINC ferrite material having low volume resistivity. A high 'Q' product for low frequencies. Has good saturation properties. Widely used in the toroidal form for high 'Q' inductors from 1 KHz to 500 KHz.

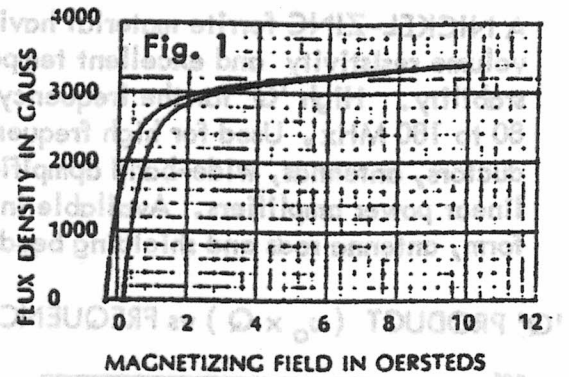
INITIAL PERM. & LOSS FACTOR vs FREQ.



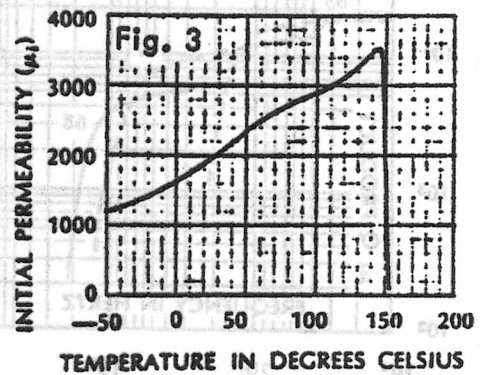
'Q' FACTOR vs FREQUENCY



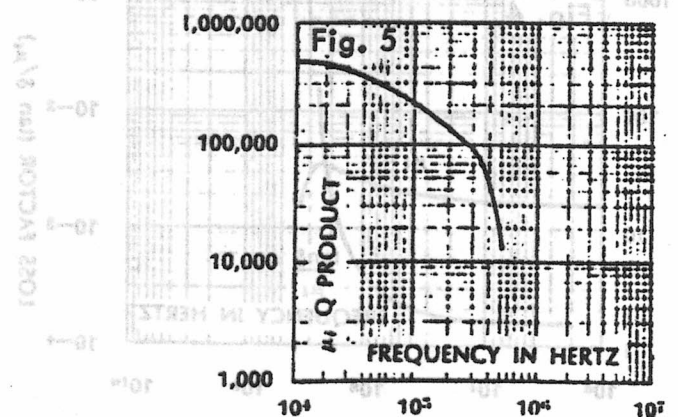
HYSTERESIS LOOP



PERMEABILITY vs TEMPERATURE



'Q' PRODUCT (u_o x Q) vs FREQUENCY



Measurements for figure 1 were made with a 1 inch outer diameter core.

Measurements for figures 2, 3, 4 and 5 were made with a half inch outer diameter core.

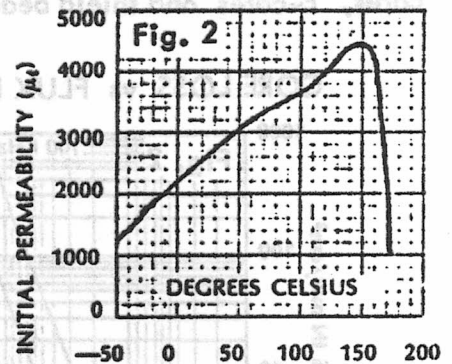
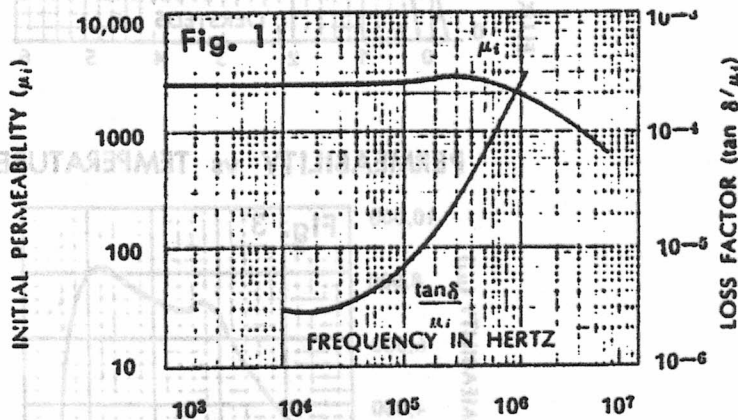
Ferrite Material #73

2500 PERMEABILITY

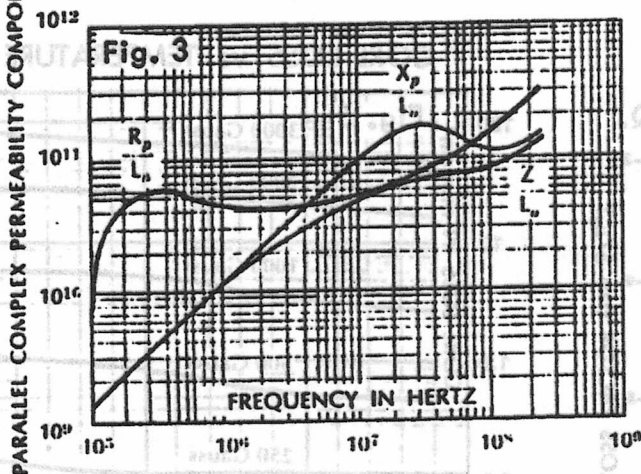
#73 MATERIAL (2500 PERMEABILITY) A MANGANESE-ZINC ferrite material having low volume resistivity. Frequency range from 1 KHz to 1 MHz, but for shield bead applications offers high impedance to frequencies from 5 to 50 MHz. Primarily used for wide-band and shield bead applications. Available in the shield bead form and the balun core configuration.

INITIAL PERM. & LOSS FACTOR vs FREQ.

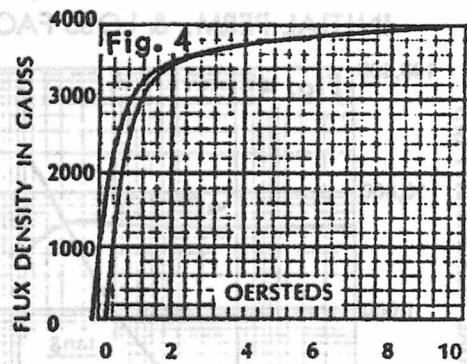
PERMEABILITY vs. TEMPERATURE



PARALLEL COMPONENTS vs. FREQUENCY



HYSTERESIS LOOP



Measurements for figures 1 and 2 were made on a .375 outer diameter core. Figure 3 shows parallel resistance, reactance and impedance for air-core inductance vs. frequency. Measured on a shield bead. Data for wide-band and shield bead applications. Measurements for figure 4 were made on a 1 inch outer diameter core.

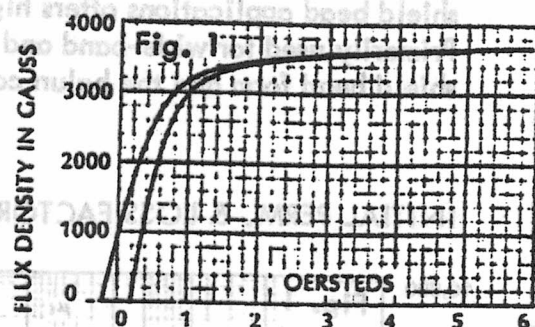
Ferrite Material #75

5000 PERMEABILITY

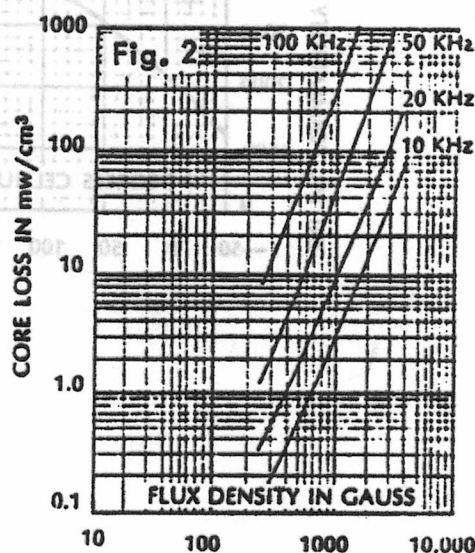
#75 MATERIAL (5000 PERMEABILITY)

A MANGANESE-ZINC ferrite material with low volume resistivity. Has low core losses from 1 KHz to 1 MHz. Used for low level power conversion transformers, wide-band transformers and pulse transformers. Also very useful for shield bead applications from 5 MHz to 20 MHz. Available in toroidal form, pot cores, E-cores and shield beads.

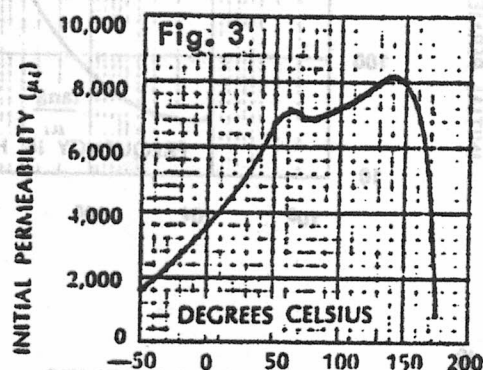
HYSTERESIS LOOP



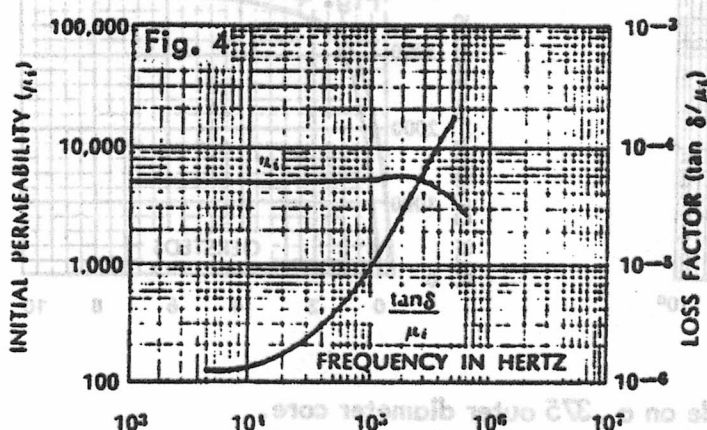
CORE LOSS vs FLUX DENSITY



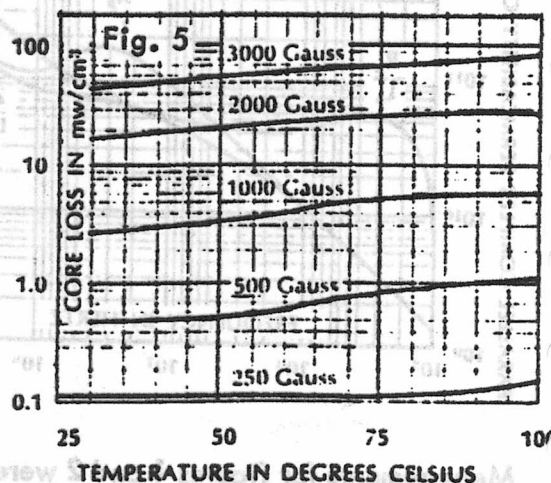
PERMEABILITY vs TEMPERATURE



INITIAL PERM. & LOSS FACTOR vs FREQ.



CORE LOSS vs TEMPERATURE



Measurements for figures 1, 2, 3 and 4 were made with a 1 inch outer diameter core. Figure 5 shows core losses at several flux densities. Measurements were made with a 1 inch outer diameter core and at 10 MHz.

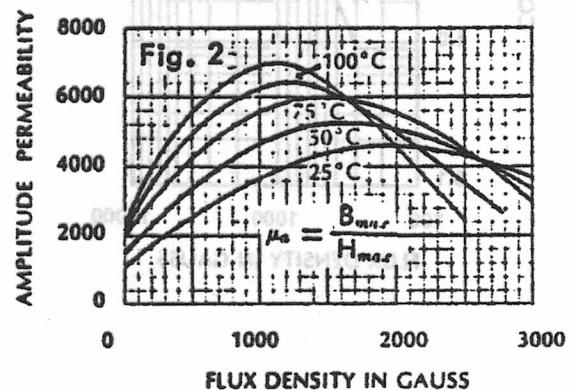
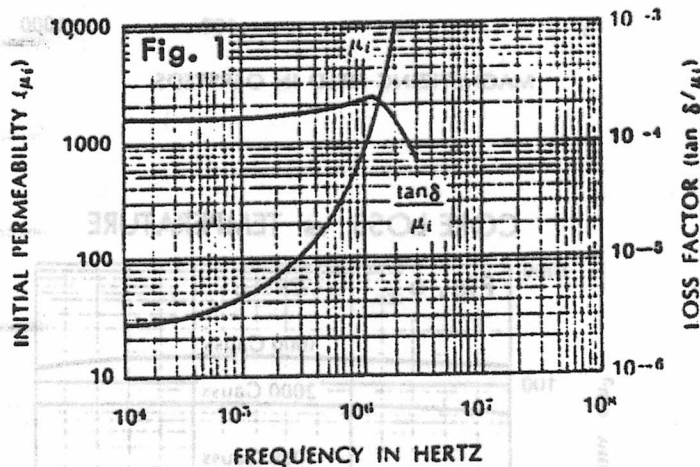
Ferrite Material 77

2000 PERMEABILITY

#77 MATERIAL (2000 PERMEABILITY) A MANGANESE-ZINC material. High saturation flux density at high temperatures. Low core losses in the 1 KHz to 1 MHz frequency range. Ideally suited for power conversion transformers, wide-band transformers up to 30 MHz and high flux density noise suppression applications in the 2 MHz to 40 MHz region. Available in toroids, shielding beads, pot - cores and E-cores.

AMPLITUDE PERMEABILITY vs FLUX DENSITY
Test core .375 OD core. Test frequency 10 KHz.

PERMEABILITY & CORE LOSSES vs FREQUENCY.
Measurements made with .375 inch O.D. core.



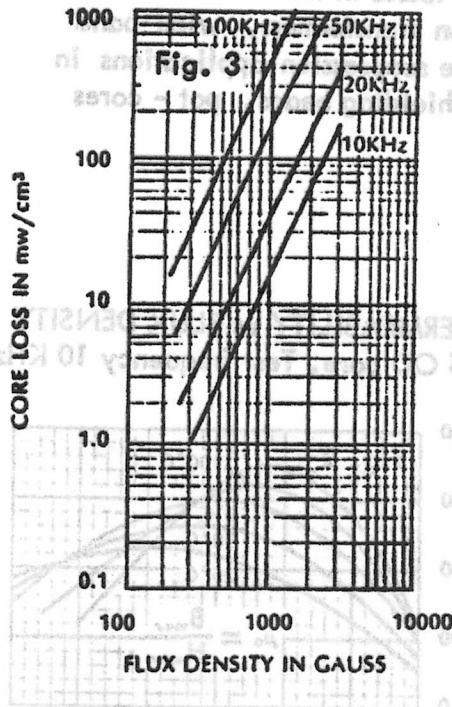
TEMP.	-25°C	0°C	23°C	50°C	75°C	100°C	125°C
B_s	4950	4725	4600	4150	3825	3450	3050
B_r	1800	1450	1150	1000	875	800	750
H_c	.30	.25	.22	.20	.18	.16	.13

Typical values of hysteresis loop parameters at various temperatures. All measurements made at $H_{max} = 10$ oersteds

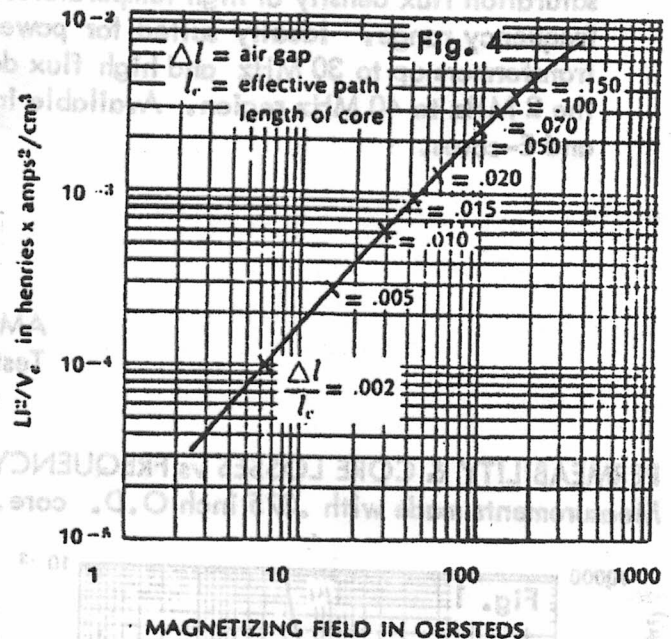
Ferrite Material //

#77 MATERIAL (2000 PERMEABILITY) continued from previous page.

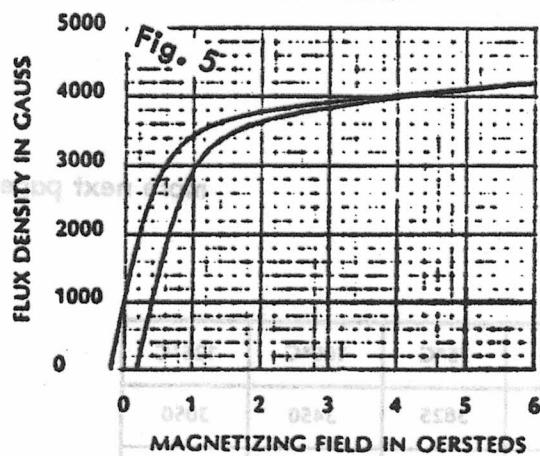
CORE LOSS vs. FLUX DENSITY



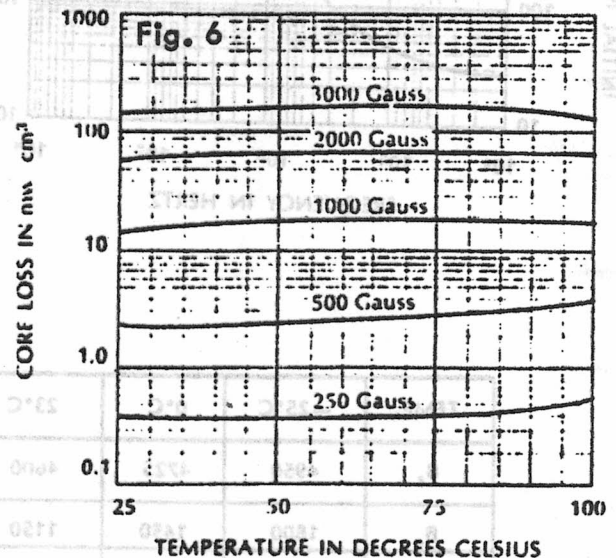
HANNA CURVE



HYSTERESIS LOOP



CORE LOSS vs TEMPERATURE



Measurements for figures 3, 5 and 6 were made with a 1 inch outer diameter core.
Figure 4: The HANNA CURVE permits calculation of inductance of gapped cores with DC current flowing in the coil.